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Green Innovation Adoption in the Construction Sector: The role of
Absorptive Capacity and the Effect of Environmental Requirements

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Abstract

This study has investigated and attempted to enhance understanding of the role of absorptive capacity in influencing a firm to adopt green innovation. Absorptive capacity which has been argued by previous study as an important factor to facilitate the adoption of innovation, may require some degree of pressure from regulators and customers, to be exerted on particular firms, to influence them to become involved in green innovation. Therefore, this study has also attempted to evaluate the extent of the moderating effect of regulatory and customer requirements on the relationship between a firm's absorptive capacity and its adoption of green innovation. A research framework was developed and three research questions were posited. An electronic questionnaire survey was created and distributed to general building firms from the construction industry in Scotland. Subsequent semi-structured interviews were conducted with a subset of participants from the survey as well as with a number of construction industry experts, to investigate further the results of the survey. A total of 84 respondents participated in the survey, while 13 respondents contributed invaluable input from the interview sessions. The findings suggest that, on the whole, the level of green innovation adoption by most of the general building firms in Scotland can be considered as relatively low. Their engagement in green-related activities, however, was focusing more on the technical and process side, which was directly influenced by firms' high levels of existing knowledge and efforts to build new knowledge through employee training. The green administrative practices, on the other hand, had not really been given attention by the building firms as it is a voluntary-based act, which does not demonstrate tangible, financial benefit to them. The evidence from the study also shows that neither environmental requirements from regulators nor customers could encourage the building firms to adopt green practices even when they have high levels of absorptive capacity. The low levels of compliance as well as poor environmental demand from the customers indicate the number one concern within the industry, that is, cost, which hinders the building firms from becoming 'greener'. Additionally, this study provided insights and further understanding regarding knowledge-based factors that could facilitate the adoption of green innovation. This study has also made a methodological contribution by providing evidence and support

for the use of mixed method approach to enhance understanding of the construction industry, which has tended to be the focus of quantitative studies. The findings of this study also have a number of implications, especially for policy makers, to explore into strategy and stringent regulations that could encourage more firms in the construction sector, which are operating in one of the industries that contributes most to environmental problems, to seek to reduce their impact on the natural environment. As the government takes a leadership role in this regard, participation from the other stakeholders within the industry is of importance to prompt a wider adoption of green practices. Here, architects, in particular, are in a potentially useful position to have a very strong influence in encouraging building firms to become involved in green practices. Besides, both individuals within the organisations (e.g. the top management and decision makers) and the society outside the organisations (e.g. customers and users of construction outputs) need to be educated to motivate them to make better environmental choices in order to contribute to environmental protection or sustainability.

Lay Summary

Green innovation is a type of innovation that has a reduced negative impact on the environment. As there is a growing concern regarding environmental impacts resulting from construction activities, green innovation is becoming seen as an important initiative contributing towards reducing the impact on the natural environment. This study has investigated an understudied factor that has been argued as important in influencing the adoption of green innovation, that is, a firm's ability to acquire, assimilate and apply related knowledge, which is called 'Absorptive Capacity'. In addition, regulator and customer pressure also play important roles in driving the adoption of green innovation. Therefore, this study has also attempted to evaluate the extent of effect of regulatory and customer requirements on the relationship between the firm's absorptive capacity and its adoption of green innovation. A survey was conducted with 84 general building firms from the construction industry in Scotland followed by subsequent interviews with six representatives of general building firms and seven construction industry experts, to investigate further the results of the survey. The findings suggest that, the level of green innovation adoption by most of the general building firms in Scotland can be considered as relatively low. The evidence from the study also shows that both environmental requirements from regulators and customers could not encourage the construction firms to adopt green innovation, even although they demonstrate high level of capability to obtain and use related knowledge. The low levels of compliance as well as poor environmental demand from the customers indicate the number one concern within the industry, that is, cost, which deters the builders from becoming more environmentally friendly. Therefore, this study suggests the policy makers to explore into strategy and stringent regulations that could encourage more firms in the construction sector, to reduce their impact on the natural environment while undertaking construction activities, which could be achieved by continuous participation of the other stakeholders within the construction industry.

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Rushanim Hashim
2018

Declaration of Originality

I declare that this thesis has been composed by myself, and it embodies the results of my own work.

It does not contain material that has been accepted for the award of any other degree in any university or professional qualification.

Following academic conventions, I have made due acknowledgement of the work of others.

.....

Rushanim Hashim

8th of September, 2018

List of Abbreviations

ANOVA - Analysis of Variance
BDS - Building Standards Division
BIS - Department of Business, Innovation and Skills
BOS - Bristol Online Survey
BRE - Building Research Establishment
BTEC - Business and Technology Education Council
CAQDAS - Computer Assisted Qualitative Data Analysis
CC - Communication Climate
CP - Customer Pressure
CPA - Construction Products Association
CSIC - Construction Scotland Innovation Centre
DECC - Department of Energy and Climate Change
DETR - Department of the Environment, Transport and the Regions
ECCI - Centre for Carbon Innovation
EDF - Environment Defence Fund
EISC - European Information Service Centre
EMS – Environmental Management System
EL - External Linkages
ES - Environmental Scanning
ET - Education and Training
FA - Factor Analysis
FMB - Federation of Master Builders
GA - Green Administrative Innovation
GP - Green Process Innovation
GT - Green Technical Innovation
GDP - Gross Domestic Product
GVA - Gross Value Added
ICT - Information and Communications Technology
ISO - International Organisation for Standardisation

KA - External Knowledge Acquisition
KB - Knowledge Building
KMO - Kaiser-Meyer-Olkin
KU - Existing Knowledge Utilisation
M - Mean
MSA - Measure of Sampling Adequacy
NGO - Non-governmental Organisation
OECD - Organisation for Economic Cooperation and Development
PCA - Principal Component Analysis
PRK - Prior Relevant Knowledge
R&D - Research and Development
RP - Regulatory Pressure
SCTG - Sustainable Construction Task Group
SD - Standard Deviation
SIC - Standard Industrial Classification
SPSS - Statistical Package for the Social Sciences
TQM – Total Quality Management
UK - United Kingdom
US - United States
VIF - Variance Inflation Factor
WWF - World Wildlife Fund
WRAP - Waste and Resources Action Programme

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CHAPTER ONE: INTRODUCTION

1.1 Research Background

This study investigates the level of green innovation adoption by Scottish building firms and the role of firms' absorptive capacity in influencing the adoption of green innovation. In addition, it seeks to assess the effect of environmental requirements in terms of regulatory and customer pressure in influencing absorptive capacity and green innovation adoption. With the increasing environmental pressure and support for modernisation, innovation has become one of the primary means by which construction companies can achieve sustainable development (Reichstein, Salter, & Gann, 2008). The concept of environmental management, that includes green innovation, is now being pursued to address these issues, particularly within the construction industry. Generally, the construction industry is known to be responsible for contributing to environmental problems. Hence, there is a need to shift from the traditional practices to more green practices (SCTG Group, 2003).

In recent years, the interest in green innovation management has been growing, both in practice and academia (Schiederig, Tietze, & Herstatt, 2012). A higher level of green innovation is generally recognised to result in a greater positive contribution to environmental protection. Therefore, it is becoming increasingly important for organisations to demonstrate their environmental awareness by "going green". Additionally, several studies have demonstrated that the adoption of green innovation practices can lead to improvement in both environmental outcomes and firm performance (Chang, 2011; Yu Shan Chen, 2008; Chiou, Chan, Lettice, & Chung, 2011). Thus, adoption of green innovation can be seen as one of the effective initiatives to contribute to environmental protection.

On the whole, green innovation is a type of innovation that reduces negative impacts on the environment. A number of different terms are used to describe this particular type of innovation. Apart from "green", the most prominent notions used in the literature to describe innovations that have a reduced negative impact on the environment are

‘eco’, ‘environmental’ and ‘sustainable’ (Schiederig et al., 2012; p.180). These terms are used interchangeably in many publications. This type of innovation normally consists of modifications or changes in strategies, production processes, product design methods, waste disposal procedures and resource consumption, in order to minimise the pressure on the natural environment (Bernauer, Engels, Kammerer, & Seijas, 2006). The growing popularity of green innovation is aligned with industries’ growing awareness and effort to protect the natural environment.

As protection of the natural environment is becoming increasingly important for the construction industry, Ofori (1992) suggested that it should be prioritised in implementing a construction project, along with cost, quality and schedule. The goal of sustainable construction highlights green innovation as a fundamental strategic tools for companies within the construction industry. Walley and Whitehead (1994) elaborated that green innovation adoption is a catalyst for constant innovation, new market opportunity and wealth creation. Reichstein, Salter and Gann (2005) added that by being green, construction companies are able to stay updated in terms of innovation and break the stereotype of the construction industry as one that is perceived to lack innovation compared to other industries. This study, therefore, focusing on the extent of green innovation adoption among firms within the construction industry.

On the other hand, the adoption of environmental or green innovation has been driven by various factors. Previous research has focused more on the external stakeholders such as regulators, customers, or environmental non-governmental organisations, rather than on firm organisational capabilities. It is fair to say that there is comparatively less empirical evidence on whether organisational capabilities enable firms to adopt such innovation. Therefore, there is a need to further understand the capabilities that form the basis for environmental proactivity (Sharma, 2005). Although such capabilities can take many forms, the ability to absorb and transform knowledge is particularly relevant to processes and products related to the environment (Russo and Fouts, 1997).

In addition, nowadays, firms are surrounded by a lot of information and relevant knowledge that is accessible at any time. The emerging role of knowledge economy has made knowledge a valuable property to firms. Thus, firms that have the capability to leverage and manipulate existing knowledge and to search for new relevant knowledge to improve their business are at an advantage. Involvement in innovation activities, including green innovation, requires new knowledge (Hordern, Börjesson, & Elmquist, 2008) to be assimilated and transformed within the organisation.

Notably, the relationship between internal knowledge building and external knowledge acquisition represents an important factor known as absorptive capacity. Defined as the ability to recognise, assimilate and exploit external new knowledge (Cohen & Levinthal, 1990), absorptive capacity is a concept that reflects the capability to utilise and develop internal knowledge and to acquire external knowledge. This capability plays an important role in influencing a firm's intention to adopt green innovation practices (Davids & Tai, 2009; Lenox & King, 2004). Therefore, I argue that absorptive capacity can help firms design or alter operations, processes, and products to reduce or prevent negative environmental impact.

These two concepts, green innovation and absorptive capacity, are the main focus of this study. As knowledge is an important asset for a firm, the capability to absorb new knowledge as well as transform and assimilate it with existing knowledge within the firm is an advantage that can facilitate the adoption of green innovation.

This chapter explores the background of the research and the reasons as well as motivation for conducting this study. It also presents the study's aims and objectives, and then elaborates on the research contribution. Finally, this chapter ends with the outline of the thesis.

1.2 Research Problem

The growing interest in environmental or green innovation has led to an increase in the number of research studies related to the area in different industries (Dutz &

Sharma, 2012). However, very few scholars have conducted research on this area within the construction industry (Gluch, Gustafsson, & Thuvander, 2009; Qi, Shen, Zeng, & Jorge, 2010; Rohracher, 2001), despite the growing concern regarding environmental impacts resulting from construction activities (SCTG Group, 2003). This situation is peculiar as environmental and sustainability issues within the construction industry require prompt and focussed attention due to its role in several severe hazards for the environment (Smallwood, 2000).

Compared with other industries, construction activities are considered to make a significant contribution to environmental problems (Ball, 2002; Tam, Tam, & Tsui, 2004; Tam & Tam, 2008). In the United Kingdom (UK), the construction sector contributed to 11.2% of the country's total greenhouse gas emissions in 2013 (Office of National Statistics, 2015). The industry also consumes around 420 million tonnes of construction material every year, whereby approximately 120 million tonnes of the materials is wasted annually (EISC, 2012). This demonstrates that the industry is not environmentally-friendly.

Nevertheless, the construction industry plays a vital role in meeting the needs of society and enhancing the quality of life. Its activities directly affect the nature, function and appearance of the place in which people live. In addition, it contributes to a better standard of living by offering employment to people all over the world. Notably, the industry makes a significant and valuable contribution to the UK economy. In particular, the UK construction industry employs 2.1 million people (Rhodes, 2015), accounting for 6.3% of total employment in the country in 2014. In the same year, the industry's output recorded an increase to £92 billion or 6.4% of the total UK economy (Office of National Statistics, 2015). Hence, the economic significance of the construction industry cannot be underestimated.

In line with these conflicting issues, it is essential for the industry to intensify its effort to move towards a model of sustainable construction. In the UK, the Department of the Environment, Transport and the Regions published a paper some 17 years ago that outlined ways for the construction industry to contribute to the achievement of more

sustainable development (DETR, 2000). The paper emphasised the importance of enhancing and protecting the natural environment and minimising the industry's impact on the consumption of energy, especially carbon-based energy, and natural resources (DETR, 2000). Furthermore, the government has set a target to achieve a 60% reduction in energy consumption by 2050 (SCTG Group, 2003). Thus, it is necessary to identify the role that the construction industry plays in protecting the environment by observing its involvement in environmental-related innovation activities or practices.

Green innovation adoption in a firm is influenced by various dynamic factors that can change over time. A number of studies have examined a range of factors that influence the adoption of green innovation such as organisational support (Ho, Lin, & Chiang, 2009; Lin & Ho, 2008; Zailani, Govindan, Iranmanesh, & Shaharudin, 2015); organisational innovativeness (Bernauer, Engels, Kammerer, & Seijas, 2006; Del Brío & Junquera, 2003; Zheng, 2014); readiness (Lee, 2008); relative advantage of particular technology (Lin & Ho, 2011; Weng & Lin, 2011); regulatory pressure (del Río González, 2005; Henriques & Sadorsky, 2007; Zailani et al., 2015); environmental uncertainty (Lin & Ho, 2008; Weng & Lin, 2011); external cooperation (Del Brío & Junquera, 2003); customer pressure (Lee, 2008; Qi et al., 2010); and competitor pressure (Henriques & Sadorsky, 2007; Huang, Ding, & Kao, 2009; Zailani et al., 2015). However, most of these factors are influenced by support or pressure from elements either internal or external to the particular organisation. As argued by Cramer (1997), firms usually became involved, by force, in environmental-related practices in order to meet certain demands, or if they perceived the practice to have direct advantages, especially in terms of cost.

The aim of this study is not to present a comprehensive model of determinants of green innovation adoption, but instead is to examine one potential determinant that has been underrepresented in the literature, namely absorptive capacity. Previous research in various industries provides evidence for the importance of absorptive capacity in facilitating the adoption of new products, processes and technologies. These studies suggest that organisations with greater capabilities in acquiring and applying

information are more likely to adopt innovations (Davids & Tai, 2009; Lenox & King, 2004; Nieto & Quevedo, 2005).

Furthermore, Hart (1995) has indicated that external knowledge is an essential requirement to implement an environmental strategy, like green innovation practices. These practices require a firm to have the ability to source and integrate knowledge, experience and materials in innovative ways (Marcus & Geffen, 1998). In addition, previous studies have shown that absorptive capacity is applicable to technical, non-technical (Lane, Koka, & Pathak, 2002) as well as environmental contexts (Lenox & King, 2004). Moreover, this type of firm capability is argued to not be very dependent on external demand, technology and other resources to enable the firms to become engaged in green innovation practices (Hordern et al., 2008). Accordingly, this research investigates the influence of a firm's absorptive capacity on the adoption of green innovation practices.

Notably, previous research showed that a majority of firms that had been involved in protecting the natural environment were motivated by specific pressures from the business environment (Gonzalez-Benito & Gonzalez-Benito, 2006). Among others, regulators and customers are two key stakeholders for firms in most industries (Christmann, 2004; Etzion, 2007). The survival of a business is normally determined by its ability to meet the requirements of these stakeholders. Nowadays, firms have to respond quickly to pressure from regulators and customers through taking environmental changes into account in their operations and decisions.

Previous studies have also found that firms perceiving greater pressure from their customers and regulators are more likely to become engaged in environmental activities (Christmann, 2004; Lee, 2008; Wong & Fryxell, 2004). Continuous pressure exerted by customers and regulators tends to motivate these firms to innovate in ways that could reduce negative impacts on the natural environment (Kleindorfer, Singhal, & Van Wassenhove, 2005; O'Brien, 1999; Sarkis, Zhu, & Lai, 2011).

Nevertheless, conflicting results are evident in previous studies on the relationship between regulatory pressure and environmental innovation (Chappin, Vermeulen,

Meeus, & Hekkert, 2009; Grubb & Ulph, 2002), as well as on the relationship between customer pressure and environmental innovation (Lin & Ho, 2011). These conflicting findings require new and complementary insights to be developed regarding the effect of regulatory and customer pressure. Accordingly, this study argues that besides absorptive capacity, regulatory and customer pressure may play an important role in driving the adoption of green innovation practices, but in the form of moderating effects.

This study addresses three research questions as follow:

Research question 1: To what extent are construction firms adopting green innovation practices?

Research question 2: How does absorptive capacity affect adoption of green innovation practices by construction firms?

Research question 3: Is the strength of the relationship between absorptive capacity of a firm and green innovation adoption contingent on the presence of regulatory and customer pressure?

In this thesis, construction firms in this study refers to firms which have people who are directly working on the building/construction sites. Slaughter (1993) argued that building firms are a main source for construction innovation and hence, they were adopted as the target participants for the current research with a particular focus on environmental innovation.

1.3 Research Aims and Objectives

This study was undertaken to enhance understanding of the challenges of engaging in green innovation within the complex business environment in the construction industry. Moreover, this study was motivated by the growing popularity of green innovation and the increasing academic interest in factors related to it. Green

innovation represents a new type of environmental management practice which is essential to the current business environment. Therefore, greater attention and research effort have to be exerted in order to achieve a better understanding of its influencing factors.

According to Chesbrough (2006) the traditional conceptual approach to innovation has gradually moved towards open innovation. This enhances significantly the role of absorptive capacity due to its capability to facilitate firms in innovation activities. This study seeks to extend the application of the absorptive capacity concept by looking at its influence on green innovation adoption. To date, the role of this interesting concept remains unclear when it linked to new environmental management practice like green innovation.

The primary objective of this study is to examine the level of green innovation adoption by Scottish construction firms. Scotland was chosen because in the past few years, the construction industry in Scotland has been active in making contributions to the Scottish Government's Low Carbon Economic Strategies (Construction Scotland, 2012). The industry players have been working collaboratively with the government, various federations (e.g. Federation of Master Builder, Scottish Building Federation), representative organisations (e.g. Bancon Group, Carillion, The Dunne Group,) and universities, to demonstrate and educate the construction participants on the benefits of sustainable construction.

Additionally, this study attempts to investigate the role of a firm's capability, called absorptive capacity, which has been identified as one of the key factors that contributes to the adoption of green innovation. In detail, this study analyses the ways in which absorptive capacity influences the adoption of green innovation practices. Besides, this study anticipates that environmental pressure has an effect on the adoption of green innovation and its relationship with a firm's absorptive capacity. Therefore, this study assesses the moderating effect of regulatory and customer pressure on the relationship between absorptive capacity and the adoption of green innovation.

1.4 Research Approach

As the research is a cross-sectional study (Creswell, 2003), the data are gathered just once. In particular, this study employed a mixed method approach for triangulation purposes. Two phases of data collection were conducted sequentially using a sequential explanatory design approach (Creswell, 2003). The data collection phase for this study started with a questionnaire survey. It was followed by a number of face-to-face interviews which were carried out in Scotland for over a period of seven months. Before starting each phase of data collection, a pilot test was conducted to evaluate the clarity and relevance of the survey and interview questions as a whole.

During the first phase of data collection, an online survey was distributed over a period of four months. The respondents consisted of persons within the building firms that held managerial position and were knowledgeable about their company's activities. Data gathered from this phase were analysed statistically using the Statistical Package for the Social Sciences (SPSS). The second phase of data collection involved face-to-face and semi-structured interviews conducted among thirteen respondents that comprised representatives of six building firms and seven industry experts. Data from these interviews provided more detail information on the involvement of Scottish building firms in green practices, in addition to the material which had been gained from the survey. Both sets of findings were then compared to address the research questions.

1.5 Significance of the Study

Linking absorptive capacity to green innovation adoption may reveal the factors motivating some firms to be more engaged in environmental-related practices than others. Moreover, deep investigation of the relationship between absorptive capacity and green innovation adoption may shed light on the conditions under which some firms are more environmental "friendly" than others. As absorptive capacity is one of the elements under knowledge management, this study strengthens the literature on knowledge content by exploring from the construction industry perspective. The

investigation of firms' behaviours regarding their intention to adopt green innovation practices that results from their capability to absorb related knowledge also benefits academicians and practitioners. In addition, a number of users may benefit from this study such as the managers of construction companies who are searching for innovation and efforts towards firm growth, venture capitalists who intend to invest in potential innovative companies and public administrators who plan the innovation and environmental policies for the country.

This research also sheds light on the ways in which project-based firms in the construction industry cultivate and implement innovation activities within their organisations. It may be possible to generalise the findings of this study to other project-based firms such as design and engineering firms. In many project-based firms, project teams have limited contact with senior management, are based off-site and work in teams with many other firms. The performance and competitiveness of these firms depend not solely on the single firm, but on the efficient functioning of the entire network. In addition, as project processes have a tendency to be temporary and unique (Gann, 1998), they present non-routine features, in contrast to traditional manufacturing approaches, which can limit opportunities for process improvement or innovation. Thus, the results related to the extent of innovation adoption and its hindrances, particularly, could be generalised to other project-based firms. In the same vein, it may be possible to generalise those particular findings of this study across other countries of similar social and economic development such as the countries in the UK itself; England, Wales and Northern Ireland. They might also apply to developed countries which exhibit similar approaches to the environment from a legal and social perspective.

Furthermore, understanding the influence of absorptive capacity on green innovation adoption can provide strategic insight into firms' corporate strategy. Moreover, this study contributes to knowledge-based and diffusion of innovation theory by providing evidence for the importance of environmental innovation practices and absorptive capabilities in the context of construction firms. In addition, the study could serve as

an important source of reference for future discussions and further research on the subject.

1.6 Outline of the Thesis

This study presents a detailed discussion of the adoption of green innovation, as well as its relationship with firm absorptive capacity and environmental requirements. The context of the research covers the construction sector, with its empirical focus on the sector in Scotland. The thesis comprises six chapters, beginning with a discussion on the background of the study and finishing with discussion on the conclusions drawn from the research.

The present chapter, **Chapter One**, has presented the introduction of the study with an overview of the research context. It began with an explanation of the research background and problem, followed by the aims and objectives of the study, the research approach and concluded with a description of the significance of the study. **Chapter Two** presents a comprehensive review of literature related to the key concepts employed in this study. In detail, it clarifies the concept of absorptive capacity and explores its relationship with green innovation adoption. The chapter also elaborates the moderating effect of environmental requirements on the relationship between absorptive capacity and green innovation adoption within the scope of the study. Additionally, a total of five main hypotheses are proposed, derived from the review of the literature.

Detailed discussion on the research design and methodology can be found in **Chapter Three** which focuses on the methods and procedures employed in carrying out the study. The development of the instruments for both the quantitative and qualitative aspects of the research, and the process adopted for their validation are also discussed in this particular chapter. Meanwhile, **Chapter Four** elaborates on the statistical procedures used to analyse the data collected from the survey. The results from the analyses are reported accordingly, along with a discussion on the descriptive data gathered from the interviews. Subsequently, the findings of the study are discussed in

depth in **Chapter Five**. Results from the survey and the materials gathered through the interviews are compared and linked to the literature to demonstrate their alignment with or deviation from the findings of previous studies. Finally, **Chapter Six** presents the conclusions derived from the empirical study. The chapter also highlights the implications and the limitations of the study. In addition, suggestions are provided for future research.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter presents a comprehensive review on the literature relevant to the concepts applied in this study. The flow of discussion begins with an introduction to the green innovation concept, followed by a detailed explanation of its relationship with a firm's capability, namely absorptive capacity. This discussion includes the effect of environmental requirements on the linkages between green innovation and absorptive capacity that informs the research framework as well. The chapter also discusses the background of the UK construction industry and examines the issues related to green innovation in the industry as a whole. Accordingly, the relevant hypotheses are formulated.

2.1 Innovation

Innovation is considered as a source of economic growth and competitive advantage. Both academics and practitioners commonly perceived that organisations should innovate to be effective and to survive in the marketplace. Innovation is studied in many disciplines and has been defined from different points of view. In a broad way, innovation is defined as the creation or adoption of new ideas (Amabile, 1988; Zaltman, Duncan & Holbek, 1973). More specifically, innovation, as described by one of the most popular innovation authors, Rogers (2003), "is an idea, practice, or project that is perceived as new by an individual or other unit of adoption" (p.12). Even though an innovation may have been invented quite a while ago, in the event that individuals perceive it as new, it may still be an innovation for them. Newness is a property of innovation in all fields. An innovation can be viewed as new to an individual adopter, a group, an organisation, an industry or the wider society (Gopalakrishnan & Damanpour, 1997; West & Farr, 1990).

At the organisational level, innovation is defined as the adoption of a new product, service, process, technology, policy, structure or administrative system (Daft, 1978; Damanpour, 1991; Zaltman et al., 1973). The adoption of innovation basically means

“full use of an innovation as the best course of action available” (Rogers, 2003, p.117), to derive anticipated benefits from changes that the innovation may bring to the organisation (West & Anderson, 1996). The adoption of innovation can be the direct result of a managerial decision or can be influenced by external factors, such as the adoption of a firm’s new structure, strategy or reward system, which might be stimulated by internal inefficiency or environmental change. At the end of the adoption process, an organisation has incorporated the new solution into ongoing practices as a means of creating change to maintain or improve the level of performance or effectiveness (Damanpour & Schneider, 2006; Zaltman et al., 1973).

The process of adoption of innovation has been studied for over 40 years. Over the years, different researchers have divided the process of adoption of innovation into a variety of phases, for instance: (1) knowledge awareness, (2) attitude formation, (3) decision, (4) initial implementation, and (5) sustained implementation (Zaltman et al., 1973); (1) awareness, (2) selection, (3) adoption, (4) implementation, and (5) routinisation (Klein & Sorra, 1996); (1) initiation, (2) development, (3) implementation, and (4) termination (Angle & Van de Ven, 2000), and (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation (Rogers, 2003). Based on these phases, this study incorporated three widely recognised phases of innovation adoption that is initiation, adoption decision and implementation (Pierce & Delbecq, 1977; Rogers, 2003; Zmud, 1982). The initiation and implementation phases have usually been distinguished by the decision to adopt, which reflect, respectively, the pre- and post-adoption decision activities of the innovation adoption process.

Initiation consists of activities related to recognising a need, searching for a solution, becoming aware of existing innovations, identifying appropriate innovations and proposing some innovation ideas for adoption (Duncan, 1976; Rogers, 2003). In this phase, organisational members learn the need for innovation, identify the opportunity to innovate, consider its appropriateness for the organisation, communicate with others and, finally, propose its adoption (Meyer & Goes, 1988). The adoption decision reflects evaluating the proposed ideas from strategic, financial and technical perspectives, making the decision to accept an idea as the desired benefit or solution,

and allocating resources for its acquisition, alteration and assimilation (Meyer & Goes, 1988). In this phase, top management decides to adopt the innovation and allocate resources for it. The final phase, that is implementation, involves actions related to preparing the organisation for the use of innovation, trial use, modifying the innovation and acceptance of the innovation (Duncan, 1976; Meyer & Goes, 1988; Rogers, 2003). In this phase, the innovation is put into use by the organisation's members.

When organisations adopt innovations, they do so with high expectations, hoping for improvements in organisational performance. However, the adoption of innovation does not ensure its successful implementation, as some organisations struggle to achieve the intended benefits of the innovation.

2.2 Absorptive Capacity and Innovation

Absorptive capacity refers to the ability to locate new ideas and to incorporate them into an organisation's processes, and this is widely seen as a major contributor to organisational performance (Cohen & Levinthal, 1990; Zahra & George, 2002). It draws attention to the need to acquire knowledge from the external environment and other inter-organisational relations, as well as focuses on internal processes of learning from past experience and current actions. This type of capability is regarded as an important factor in both innovation and competitive advantage.

Organisations differ in their ability to assimilate and replicate new knowledge gained from external sources. It has been argued by Cohen and Levinthal (1990) that absorptive capacity tends to develop cumulatively and builds on prior related knowledge. Organisations that possess relevant prior knowledge are likely to have a better understanding of new technology that can generate new ideas and develop new products. Organisations with a high level of absorptive capacity are likely to harness new knowledge from other organisations to help their innovative activities. For example, in a case study of two large multinational corporations, Tsai (2001) found that absorptive capacity significantly affects organisations' innovation as well as their performance. Similar result has been revealed by McKelvie, Wiklund & Short (2007) in their study where it has been shown that there is a significant linkage between

absorptive capacity and innovation. In addition, there are some more research studies which have looked into the relationship between absorptive capacity and innovation (e.g. Adams, Bessant & Phelps, 2006; Hagedoorn, Roijakkers & Van Kranenburg, 2006; Phene, Fladmoe-Lindquist & Marsh, 2006). Therefore, as the effect of absorptive capacity is more complex than articulated in literature, this concept and its relationship with innovation is worth being further investigated. This study, however, is focusing on the relationship between absorptive capacity and a particular type of innovation that is green innovation.

2.3 Firm Size and Age: Their Relation with Innovation

Many have debated about who is better at innovating. Researchers have argued about the relevance of various firm characteristics for innovative effort and associated performance. In an innovation-related research study conducted by Nelson (1991), titled "Why Do Firms Differ, and How Does It Matter?", he argued that "it is organizational differences, especially differences in abilities to generate and gain from innovation" (p.72), which directly related to firm characteristics. Commonly studied firm characteristics include size (Acs & Audretsch, 1987; Lepoutre & Heene, 2006) and age (Calantonea, Cavusgila & Zhao, 2002; Zhou & Wu, 2010). Firm size is one of the most widely debated regarding its impact on innovation. On the relationship between firm size and innovation, Schumpeter alone is credited with one popular view that is large firms with some degree of monopoly power are the most likely to innovate (Afuah, 1998). In general, size can affect a firm's innovation and performance. Large firms tend to have more resources with which to enhance their innovation and performance. They are also usually more powerful than small firms are and have some advantages in gaining the top managements' support for their business operations and innovation activities.

Another line of literature has focused on the impact of the underlying growth process rather than on firm size itself. Specifically, it examines the link between firm age and innovation effort. This line of research suggests that older firms may or may not be better at innovating than younger firms. While a study conducted by Huergo and

Jaumandreu (2004) has shown that entrant or younger firms tend to present the highest probability of innovation than older firms, Sørensen and Stuart (2000, p.85) suggest that “older firms will have perfected the routines, structures, incentive programs, and other infrastructure that are needed to develop new technologies and bring them to market”. These are some arguments that may explain the need of further investigating the age factor and its relationship with innovation.

Therefore, both firm characteristics, firm size and age, have emerged as important factors in previous innovation-related studies, which need to be considered in this study as well.

2.4 Green Innovations

As the word ‘green’ has gained popularity in many areas, numerous scholars and practitioners have undertaken research on the topic (Bernauer et al., 2006; Chang, 2011; De Marchi, 2010). A large number of scientific studies exploring the notion of ‘green’ have been published across different fields and industries (Ball, 2002; Qi et al., 2010; Tam & Tam, 2008; Thorpe, Ryan, & Charles, 2008), with an average of 150 per year since 2005 (Schiederig et al., 2012), with the majority of these studies focused on the concept of green innovation.

In addition, growing concern regarding different aspects of environmental impact at present has forced firms to reconsider their approach towards the environment with more ambitious targets. ‘Going green’ has been claimed to be a great business opportunity (Hart & Milstein, 1999), and increases the value of an organisation (Porter & Kramer, 2006). In fact, Eiadat, Kelly, Roche, and Eyadat (2008) found a positive relationship between the adoption of green innovation strategies by a firm and its overall performance.

According to Leenders and Chandra (2013), green innovation is a reflection of two broad concepts: environmental management and innovation. Green innovation takes place when a firm focuses on maintaining or improving the natural environment while

engaging in innovation-based activities. This type of innovation generally aims to improve current environmental performance or gain competitive advantage through the introduction or improvement of technologies, processes or administrative practices.

A number of different definitions exist for green innovation but they carry fairly similar meaning and values. For instance, researchers have labelled the concept as ‘environmental innovation’, ‘eco-innovation’ and ‘sustainable innovation’ (Hedstrom, Keeble, Lyon, Pardo, & Vassallo, 2005; Kemp et al., 2007; OECD, 2008). These definitions slightly vary and can be categorised into three broad groups as shown in Table 2.1.

Table 2.1: Definition of ‘green innovation’

Views	Definitions	Author(s)
Reduction of environmental impact	Green innovation can be defined as “new products and processes which provide value to the customer and business, while significantly decrease environmental impacts”.	James (1997; p52)
	Environmental innovation is a “new or modified process, technique, practice, system, and product that avoids or reduces environmental harm”.	OECD (2006; p15)
	Eco-innovation is “the production, assimilation or exploitation of a product, production process, service, management or business method that is novel to the organisation. Its development or adoption results in reduced environmental risk, pollution and other negative impacts of resources usage (including energy usage) compared to relevant alternatives throughout its lifecycle”.	Kemp et al. (2007; p7)

Table 2.1: Definition of ‘green innovation’ (continued)

Views	Definition	Author (s)
Improvement of environmental performance	“As a subset of innovation, environmental innovation orientates the direction of innovation towards environmental improvements”.	Mirata & Emtairah (2005; p995)
	Green innovation is defined as “hardware or software innovation that is related to green products or processes, including innovation in technologies that are involved in (i) saving energy, (ii) preventing pollution, (iii) recycling waste, (iv) green product designs, or (v) corporate environmental management”.	Chen, Lai & Wen (2006; p332)
	“Environmental innovation encompasses all innovations that have a beneficial effect on the environment regardless of whether this effect was the main objective of the innovation”.	OECD (2008; p14)
Creation of environmental performance	Green innovation may “include the development or implementation of new products, technologies, production processes, resources, markets and systems that integrate economy and ecology”.	Blattel-Mink (1998; p49)
	“Sustainability-driven innovation means the creation of new market space, products and services or processes driven by social, environment or sustainability issues”.	Hedstrom. et al. (2005; p9).

Source: Developed by the author

From Table 2.1, green innovation is contended to reduce environmental impact (James, 1997; Kemp et al., 2007; OECD, 2006), improve environmental performance (Chen, Lai, & Wen, 2006; Mirata & Emtairah, 2005; OECD, 2008) or create environmental performance (Blattel-Mink, 1998; Hedstrom et al., 2005). Based on reviewed definitions, this study proposes a definition of green innovation that suits the research context: the introduction, modification or adaptation of any technologies or processes as well as the implementation of administrative practices that limit or reduce

negative impacts on the natural environment. This definition reflects a proactive viewpoint by highlighting the contribution in reducing environmental impacts.

Green innovation has been a debated subject between two schools of thought. The first view which has become increasingly obsolete states that environmental management is very costly (Gallarotti, 1995). This traditional view has shaped the mind-set of most organisations to perceive that environmental management is an unnecessary investment and would affect their profitability and growth (Chen & Chang, 2013). Conversely, the second view elaborates the benefits of adoption of green innovation. This environmental-friendly initiative creates a lot of benefits for the innovator firms, while also contributes to positive effects on the environment. The latter argument appears to dominate the latest researches which mainly focused on the benefits of green innovation, namely, publicising a good corporate image, promoting collaboration with external partners, improving key performance indicators, ensuring regulation compliance and adding value to core competencies (Chen, 2008; Maynard, 2008; Zhu, Sparks, & Geng, 2004).

Generally, a firm's activities that can impact the natural environment negatively are mainly determined by the types of materials or energy used during particular activities, technologies or equipment installed and environmental strategies. Therefore, in order to be greener, a firm has to minimise the environmentally negative impact that its activities have on the environment by becoming innovative at several levels. Table 2.2 highlights the main categories of green innovation at different levels of a firm's operation.

Table 2.2: Main Categories of Green Innovation

Green Innovation	Strategies
Product	<ul style="list-style-type: none"> • Changing the existing product for a greener alternative. • Totally or partially recycling or reusing products or their parts.
Resources	<ul style="list-style-type: none"> • Reducing the usage of natural resources. • Minimising energy consumption. • Using renewable energy.
Production/operation	<ul style="list-style-type: none"> • Reconfiguration of the existing production chains. • Introducing efficient process loops.
Technology	<ul style="list-style-type: none"> • Substituting or transforming the existing technology with a cleaner alternative in order to reduce or eliminate solid waste, liquid waste and polluting emissions.
Equipment	<ul style="list-style-type: none"> • Substituting or transforming the existing equipment with a greener alternative in order to reduce or eliminate solid waste, liquid waste and polluting emissions.
Waste	<ul style="list-style-type: none"> • Reducing, recycling and reusing waste to avoid or reduce serious pollution of air, soil, water, and other environmental resources.
Pollution	<ul style="list-style-type: none"> • Reducing the negative environmental impacts of company's activities on air, water, and soil.

Source: Sarmento, Dura~o and Duarte (2007)

In this study, green innovation practices are classified into three main categories: green technical innovation, green process innovation and green administrative innovation (Chen, Lai, & Wen, 2006; Chen, 2008; Chiou, Chan, Lettice, & Chung, 2011; Huang et al., 2009; Tseng, Wang, Chiu, Geng, & Lin, 2013). From the technical perspective, green innovation involves application of environmentally-friendly equipment and

technologies that reduce the negative impacts on the environment (Huang et al., 2009). It refers to the transition from older technologies to cleaner technologies. Moreover, green process innovation is any adaptation of the construction process, such as savings on material, recycling waste, and decreasing energy usage, that reduces the negative impact on the environment (Chen, 2008). As explained by Cheng and Shiu (2012), it involves the addition of new processes or improvement of existing processes to reduce environmental impact.

Administrative innovation refers to the introduction of a new administrative process, management system or staff development programme. These innovations that occur in the administrative components affect the social system which consists of the organisational members and their relationships (Subramanian & Nilakanta, 1996). From the environmental perspective, administrative innovation can occur in the form of new procedure, policy and organisational approach that promotes the importance of environmental considerations (Ussahawanitchakit, 2012). Anderson and Manseau (1999) added that administrative innovation from the environmental viewpoint comprises changes to organisational structures, implementation of advanced management systems and techniques, and introduction of a new corporate strategic orientation towards reducing environmental impacts.

2.5 Absorptive Capacity as the Driver of Green Innovation Adoption

A number of studies have focused on identifying the drivers or determinants of green innovation practices (Bernauer et al., 2006; Del Brío & Junquera, 2003; Henriques & Sadorsky, 2007; Ho, Lin, & Chiang, 2009; Huang et al., 2009; Lee, 2008; Lin & Ho, 2008; Lin & Ho, 2011; Qi et al., 2010; Weng & Lin, 2011; Zailani et al., 2015). Table 2.3 summarises the factors recognised by previous studies as influencing a firm's willingness to engage in green-related practices.

Table 2.3: Previous Studies on Determinants of Green Practices

	Factor(s)	Author(s)
Organisational factors	Organisational support	Lin & Ho (2008), Huang et al. (2009), Ho et al. (2009), Qi et al. (2010), Lin & Ho (2011), Weng & Lin (2011), Zailani et al. (2015)
	Quality of human resources	del Brio & Junquera (2003), Lin & Ho (2008), Ho et al. (2009), Lin & Ho (2011), Weng & Lin (2011)
	Management style	del Brio & Junquera (2003), Jamaludin, Ahmad, & Ramayah (2012)
	Employee pressure	Henriques & Sadorsky (2007), Huang et al. (2009), Qi et al. (2010)
	Company size	Bernauer et al. (2006)
	Green capabilities/ green-related knowledge	Bernauer et al. (2006), Lin & Ho (2008), Ho et al. (2009)
	Organisational innovativeness	Del Brio & Junquera (2003), del Rio Gonzalez (2005), Bernauer et al. (2006), Zheng (2014)
	Organisational structure	Büschgens, Bausch, & Balkin (2013). Del Brio & Junquera (2003), del Rio Gonzalez (2005), Jamaludin et al. (2012)
	EMS/TQM implementation	Henriques & Sadorsky (2007)
	Financial resources	Del Brio & Junquera (2003), del Rio Gonzalez (2005)
	Explicitness of green practices	Lin & Ho (2008)
	Readiness	Lee (2008)
Technological factors	Relative advantage	Lin & Ho (2011), Weng & Lin (2011)
	Compatibility	Lin & Ho (2011), Weng & Lin (2011)
	Complexity	Lin & Ho (2011), Weng & Lin (2011)

Table 2.3: Previous Studies on Determinants of Green Practices (continued)

	Factor(s)	Author(s)
Environmental factors	Regulatory pressure	del Rio Gonzalez (2005), Bernauer et al. (2006), Henriques & Sadorsky (2007), Huang et al. (2009), Lin & Ho (2011), Weng & Lin (2011), Zailani et al. (2015)
	Governmental involvement/ support	Lin & Ho (2008), Lee (2008), Lin & Ho (2011), Weng & Lin (2011)
	Community/ environmental organisation pressure	del Rio Gonzalez (2005), Henriques & Sadorsky (2007), Huang et al. (2009), Qi et al. (2010)
	External cooperation	Del Brio & Junquera (2003)
	Environmental uncertainty	Lin & Ho (2008), Lin & Ho (2011), Weng & Lin (2011)
Market factors	Customer pressure	del Rio Gonzalez (2005), Bernauer et al. (2006), Henriques & Sadorsky (2007), Lee (2008), Huang et al. (2009), Qi et al. (2010), Weng & Lin (2011), Zailani et al. (2015)
	Competitor pressure	del Rio Gonzalez (2005), Bernauer et al. (2006), Huang et al. (2009)
	Supplier involvement/ pressure	del Rio Gonzalez (2005), Henriques & Sadorsky (2007), Huang et al. (2009)

Source: Developed by the author.

Notably, the factors associated with the adoption of green innovation are similar in several studies. In addition, most studies focused on organisational factors as the determinants of green innovation adoption. The table also indicated that a majority of the studies investigated the association between organisational support (Ho et al., 2009; Huang et al., 2009; Lin & Ho, 2008; Lin & Ho, 2011; Qi et al., 2010; Weng & Lin, 2011; Zailani et al., 2015) and quality of human resources (Del Brío & Junquera, 2003; Ho et al., 2009; Lin & Ho, 2008; Lin & Ho, 2011; Weng & Lin, 2011) with the adoption of green innovation practices. Meanwhile, others researchers examined the link of the adoption of green practices with green capabilities (Bernauer et al., 2006;

Ho et al., 2009; Lin & Ho, 2008), organisational innovativeness (Bernauer et al., 2006; Del Brío & Junquera, 2003; del Río González, 2005; Zheng, 2014) and company size (Bernauer et al., 2006).

Despite the fact that most studies had examined a number of organisational factors that influence the adoption of green innovation, very few studies had addressed the association between organisational capabilities in terms of the firm's absorptive capacity, and green innovation adoption. The current study argues that the intention to become involved in green innovation practices will depend on the organisational capabilities to acquire, assimilate and apply related knowledge. This argument is strengthened by a survey-based research conducted by Lin and Ho (2008) who found that relevant knowledge obtained by a firm plays an important role in the adoption of green innovation. This result was also supported by Bernauer et al. (2006).

However, there is relatively little empirical evidence to prove that absorptive capacity enables firms to adopt green innovation practices; only two studies were found on the topic. First, Lenox and King (2004) examined the role of absorptive capacity in facilitating the implementation of pollution prevention practices among Information and Communication Technology (ICT) manufacturers in the United States (US). Second, Davids and Tai (2009) performed a case study of Dutch State Mine and found that acquisition and assimilation of external knowledge are essential to improve the existing coal cleaning process.

Nowadays, the rapid improvement in technology and business activities has encouraged firms in various industries to enhance their competencies by being involved in innovative activities. Additionally, the emerging role of the knowledge economy has elevated 'knowledge' as a valuable property which has become a critical part of enhancing such competencies. Knowledge can be considered as a stimulus for the introduction of new practices. Hence, involvement in any type of innovative activity requires firms to vigorously and meticulously accumulate and assimilate internal and external knowledge.

In fact, the traditional conceptual approach to innovation is being gradually changed to the model of open innovation proposed by Chesbrough (2006) as firms are increasingly focused on employing internal and external knowledge, as well as ideas in order to create innovative outcomes (Juceviciene & Ceseviciute, 2009). As a result, apart from internal knowledge, firms increasingly rely on external knowledge to foster innovation and to enhance their performance (Ireland, Hitt, & Vaidyanath, 2002).

Similarly, green innovation requires new knowledge (Hordern et al., 2008) that needs to be assimilated and transformed throughout the organisation as a prerequisite for its successful implementation. Besides enhancing their existing knowledge, firms have to develop their capability to acquire new knowledge in order to foster innovation. This brings forward the concept of absorptive capacity. Defined by Cohen and Levinthal (1990) as the ability to recognise, assimilate and exploit new external knowledge, absorptive capacity is a concept that reflects the capability to utilise and develop internal knowledge, as well as the capability to acquire external knowledge. This basic definition is widely accepted because it is simple, easily comprehensible, and covers the main idea of the concept very well.

Furthermore, absorptive capacity has been considered by most scholars as a representation of two standpoints: as a stock of existing knowledge and as the ability to absorb new knowledge (Roberts, Galluch, Dinger, & Grover, 2012). The literature review also revealed that absorptive capacity has been defined in various ways. For example, investment in internal research and development (R&D) was considered as a well-known proxy of absorptive capacity in many empirical studies (Oltra & Flor, 2003; Veugelers, 1997). This is in line with Cohen and Levinthal (1990) who claimed that 'R&D contributes to a firm's absorptive capacity' (p. 128). Nonetheless, investment in R&D is not the only relevant or the most important dimension of absorptive capacity.

From a broader perspective, knowledge creation is not only related to investment in R&D, but it covers all of the activities related to searching and acquiring knowledge. Apart from R&D investment, several other key features of a firm's absorptive capacity had been suggested: individual skills and qualification, prior relevant knowledge,

organisational culture, human resource management practices, openness to external knowledge and external linkages (Ahuja, 2000; Cohen & Levinthal, 1990; Kastelli, Caloghirou, & Ioannides, 2004; Macduffie, 1995; Van den Bosch, Volberda, & de Boer, 1999; Vega-Jorado, Gutierrez-Garcia, & Fernandez-de-Lucio, 2008).

The balance between internal knowledge building and external knowledge acquisition is a key factor of the development of a firm's capabilities. The knowledge acquisition activities are closely related to the internal knowledge building of a firm. Without the appropriate internal knowledge base, it is difficult for a firm to scan the environment for relevant knowledge from external sources. Hence, the concept of absorptive capacity reflects the relationship between internal knowledge building and external knowledge acquisition, along with their continuous interaction.

In addition, absorptive capacity has been suggested by researchers as a concept that links knowledge generated outside the company to knowledge generated within the company (Nieto & Quevedo, 2005; Williander, 2007), which is one of the prerequisites to realising innovation activity. The concept refers to the ability of a firm to recognise useful, new external knowledge and to assimilate it by building on prior knowledge which has been embedded within the firm (Caloghirou, Kastelli, & Tsakanikas, 2004; Koch & Strotmann, 2008). These factors are derived from specific mechanisms of knowledge creation and knowledge transfer. They reflect the intensity of efforts made by a firm to develop organisational knowledge and acquire knowledge from external sources.

Absorptive capacity has been shown to play an important role in realising the implementation of innovation, particularly green innovation. For that reason, the organisational capabilities that generate a firm's intention to be involved in green innovation practices need to be comprehended further. Among others, a firm's abilities to absorb environment-related knowledge and to learn how to develop processes that enable them to absorb such knowledge are identified to be extremely crucial.

2.6 Theoretical Perspectives on the Adoption of Green Innovation and its Relationship with Absorptive Capacity

In order to understand the decision-making process towards innovation adoption, it is important to investigate the factors that drive or hinder the development and adoption of innovation (Van de Ven, 1986). Tornatzky and Fleischer (1990) recommended that researchers should not only consider the innovation, but also pay careful attention to the context within which an innovation takes place as well. Furthermore, the literature highlighted that the factors influencing innovation adoption are also important in the diffusion and adoption of green innovation.

In the field of innovation management, diffusion theory that concentrates on the diffusion and adoption of innovation is a renowned topic which has been discussed frequently (Allan, Jaffe, & Sin, 2014). While diffusion involves the process in which a new practice is accepted and used by its user, adoption involves the process where a user identifies and implements a new practice (Rogers & Shoemaker, 1971). From the perspective of the adopting unit, diffusion and adoption generally pass through a similar process. They are closely related to a decision process that begins with identifying a stimulus for actions and ends with giving the commitment to action (Mintzberg, Raisinghani, & Theoret, 1976).

In their attempt to explore this concept, researchers have developed several models that demonstrate different approaches towards diffusion or adoption of innovation. Starting with “classic diffusion theory” presented by Rogers (1962), four elements involved in a diffusion process were introduced: (i) an innovation, which refers to something perceived as new, (ii) a communication system, which consists of a transmission system from individual, group or society to another, (iii) a social system, which encompasses a set of individual, groups or organisations that are engaged in joint problem solving that provides the domain for diffusion, and (iv) time, which refers to the period begin with the initial awareness of innovation until the saturation of its adoption.

Another framework was developed by Tornatzky and Fleischer (1990), which includes three factors that affect innovation adoption by organisations, namely technological

context, internal context of the firm and external (environmental) context. The technological context mainly emphasises the influence of innovation characteristics on its adoption. The internal context of the firm covers various firm characteristics such as formalisation, centralisation, organisational complexity, slack resources, and size that might facilitate or hinder the adoption of innovation (Tornatzky & Fleischer, 1990). Moreover, the external context, focuses on a firm's operation area and includes its interaction with other elements such as competitors, suppliers, customers, regulators, other stakeholders of the industry and environmental uncertainty. All of these factors may facilitate or hinder the adoption of innovation (Chau & Tam, 1997; Hashem & Tann, 2007; Tornatzky & Fleischer, 1990).

This framework offers better understanding for the process of decision making and innovation adoption, particularly for this study. As explained by Fichman (1992), the diffusion of innovation theory provides “concepts that are developed well and a large body of empirical results applicable to the study of technology evaluation, adoption and implementation” (p.1). This is clearly relevant to this study which focuses on the adoption of green innovation in terms of technology, process and administration.

In the research's attempt to examine the role of absorptive capacity in facilitating the adoption of green practices, it also draws upon another primary research theory, that is, the knowledge-based theory of the firm. As absorptive capacity is an element under the knowledge management field, its relationship with green innovation could be investigated by looking from the lens of knowledge-based theory. Therefore, both diffusion of innovation and knowledge-based theory are used to develop the research model and associated propositions for the current study.

An important assumption that is derived from the fundamentals of knowledge-based theory is that knowledge is the primary source of value (Grant, 1996). By linking it to innovation, the basic premise of this theory suggests that the introduction of a new product (innovation) is mainly dependent on the firm's ability to create, manage and maintain knowledge. The focus of early research on knowledge-based theory was mainly on the general effect of knowledge on innovation (Bierly & Chakrabarti, 1996; DeCarolis & Deeds, 1999). In contrast, more recent studies put greater emphasis on

the importance of a firm's knowledge base as valuable and unique resources for innovation development (Miller, Fern, & Cardinal, 2007; Subramaniam & Youndt, 2005; Zhou & Wu, 2010).

In general, absorptive capacity is a concept that is closely related to knowledge and learning. According to the knowledge-based theory, a firm can be seen as a knowledge repository whereby knowledge has been identified as a key factor that contributes to the success of the firm (Spender, 1996). Moreover, the internal knowledge accumulation derived from organisational learning effort drives the value creation that reflects the firm's openness to new opportunities which further increases its ability to exploit those opportunities (Spender & Grant, 1996). Thus, from a knowledge perspective, this organisational advantage is represented by a firm's ability to acquire, understand and exploit knowledge which is known as absorptive capacity (Cohen & Levinthal, 1990). A firm that develops and maintains its absorptive capacity is able to retain a large stock of knowledge. Grant (1996) contended that this could contribute to successful innovation or the introduction of new practices.

2.7 Context of Study – The Construction Industry

Much of the literature has often classified construction as “low-tech” and “traditional” industry (Miozzo & Derwick, 2004; OECD, 2000; Reichstein et al., 2008). These studies have recognised the common attributes of construction firms which are considered as conservative, risk averse, engaging in low investment of R&D, have few operating routine and the development of new technology or product is mostly dominated by suppliers. The industry has many small firms with few professional staff and is dominated by price-based competition among contractors to win a particular project (Gann, 2000). As highlighted by Gann (2000), construction has shown lower productivity growth and has continued with more labour intensive approaches compared to other industries. This dominant perspective implies the modest importance of innovation sources in construction, given the reflection of a slow pace of change in the industry. Looking at its distinctive features, construction is a project-based sector, the products is durable, it uses temporary coalitions of organisations to

complete a unique project, most of its productions and assemblies are “in-situ¹” (Allen & Iano, 2013), and it has a high level of client involvement especially during the design and production phase (Pinto, 2016). These factors have shaped its activities and significantly influence its innovative effort.

In addition, the construction industry and its activities are considered to be one of the major sources of development and economic growth. The industry plays an important role in the development of a country by improving economic and social areas in many ways. For instance, it offers job opportunities to millions of workers, generates income within and outside of the sector, and supplements the foreign exchange earnings from trade in construction materials and engineering services. The condition of the construction industry affects, to some extent, most common economic measures of a country, like Gross Domestic Product (GDP)². It would also affect the availability of capital, government’s decisions, and even the social health of a country. Besides, the construction industry has significant interaction with other economic sectors through its linkages.

The ‘output’ of the construction sector provides the necessary private physical structures and public infrastructure for various productive sectors such as services, commerce, utilities and other industries. The activities of the industry transform various resources into constructed facilities through planning, design, construction, maintenance and repair, as well as operations. These facilities, which range from residential and non-residential buildings to heavy construction, play a critical role in the development of a country (Kheni, Gibb, & Dainty, 2008).

Pearce (2003) explained that the construction industry has both narrow and broad definitions as presented in Figure 2.1. The narrow definition emphasises the contractors’ on-site construction activities. By contrast, the broad definition covers the true extent of the industry, including the quarrying of construction raw materials,

¹ ‘In-situ’ in construction context means ‘on construction site’.

² Gross domestic product (GDP) is a measure of the total expenditure of a country on goods and services within a certain time (normally a year).

manufacturing of building materials, the sale of construction products and various services provided by associated professional within the industry (Pearce, 2003).

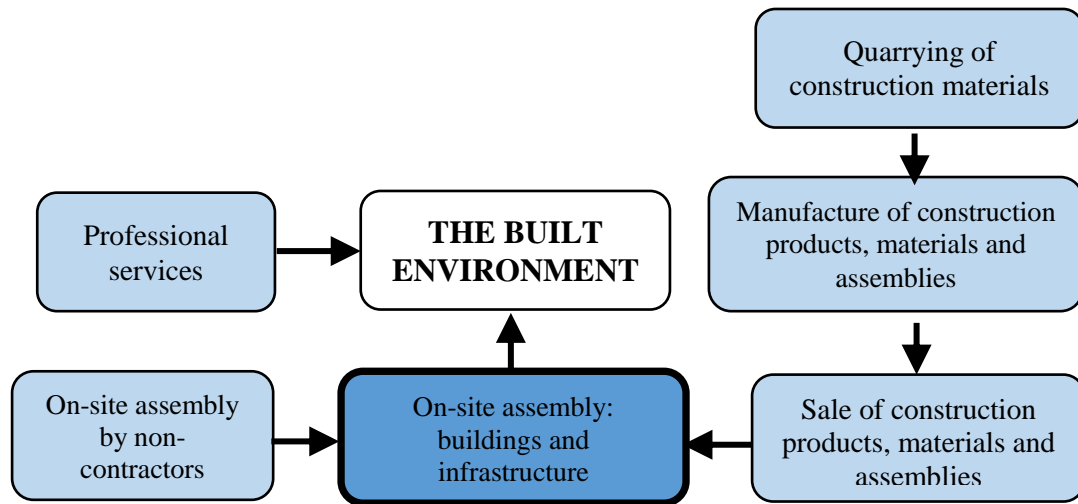


Figure 2.1: The Component of the Construction Industry
Source: Pearce (2003).

The highlighted box with bold line in Figure 2.1 shows the traditional, narrow definition of the construction industry. It focuses the essential role of on-site contractors, who are involved directly in the assembly and repair of building and infrastructure. Specifically, the activities include site preparation, construction of buildings and civil engineering works, building installation and building completion, done by contractors, in-situ. This definition corresponds to the Standard Industrial Classification (SIC) category 45 used in official statistics in the UK (Office of National Statistics, 2003). The current research adheres to this traditional definition as it seeks to answer the research questions.

Regardless of the definition, the main aim of the construction industry is to serve and maintain the built environment. The built environment encompasses all buildings, spaces and products that are built by people within the construction industry. Examples of the built environment are houses, schools, workplaces, parks, business areas, farms, and roads. Furthermore, construction activities generally consist of design, planning,

construction, and maintenance of a building. These activities could enhance the built environment while contributing to the economy and society as a whole. As shown in Figure 2.2, construction covers many different types of work such as projects for private individuals, commercial property development, public infrastructures, building services, and maintenance of existing buildings.

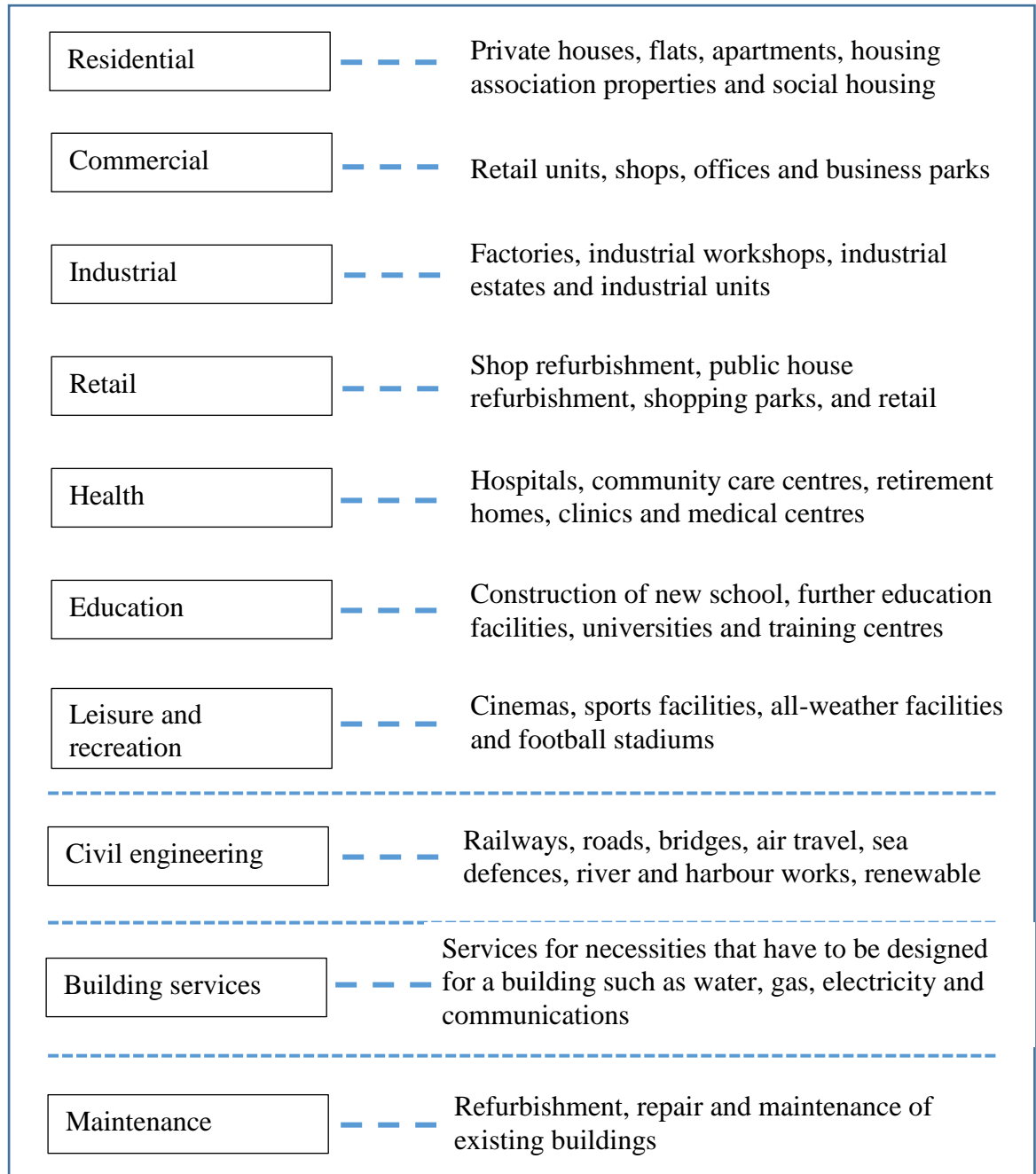


Figure 2.2: Types of Construction Work
Source: BTEC First (2003)

These project-based construction works that are delivered to the built environment involve numerous participants whose responsibilities are defined according to contracts. The major participants in typical construction projects are architects, engineers, consultants, contractors, subcontractors, construction workers and owners or customers who have spent their money on the constructed facilities (Isa, Jimoh, & Achuen, 2013). These participants deliver a variety of outputs including visible facilities which contribute to the economy of a country in several ways. The following section will discuss the economic contribution of the UK construction industry.

2.7.1 Economic Significance of the UK Construction Industry

As one of the largest sectors in the UK economy, the construction industry contributed almost £92 billion or 6.4 % in value added economic output in 2014, providing 2.1 million jobs which was equivalent to 6.3% of the total employment in the UK (Rhodes, 2015). The industry makes substantial contribution to the country's development process. The contribution of the construction industry to the UK economy can be measured by its gross value added (GVA) which only considers the actual added value of the industry. The economic contribution of the UK construction industry is presented in Table 2.4.

Table 2.4: Contribution (GVA) of the Construction Industry to the UK Economy

Year	£ billion	% change	% of economy
2000	82	0.9%	6.1%
2001	83	1.8%	6.2%
2002	88	5.7%	6.6%
2003	92	4.8%	6.8%
2004	97	5.3%	6.8%
2005	95	-2.4%	6.8%
2006	96	0.8%	6.8%
2007	98	2.2%	6.9%
2008	95	-2.6%	6.6%
2009	83	-13.2%	6.0%
2010	90	8.5%	6.0%
2011	92	2.2%	6.3%
2012	85	-7.5%	6.0%
2013	86	1.4%	6.0%
2014	92	7.4%	6.4%

Source: Office of National Statistics (2015)

Historically, the UK construction industry has been affected significantly since the recession in 2008. Its output fell faster than the rest of the economy in 2008 but recovered more rapidly than the economy as a whole in the following year, 2009. Both 2010 and 2011 witnessed generally flat growth, followed by another contraction in 2012 and partial recovery through 2013. The sector then grew steadily through 2013 and 2014 as illustrated in Figure 2.3.

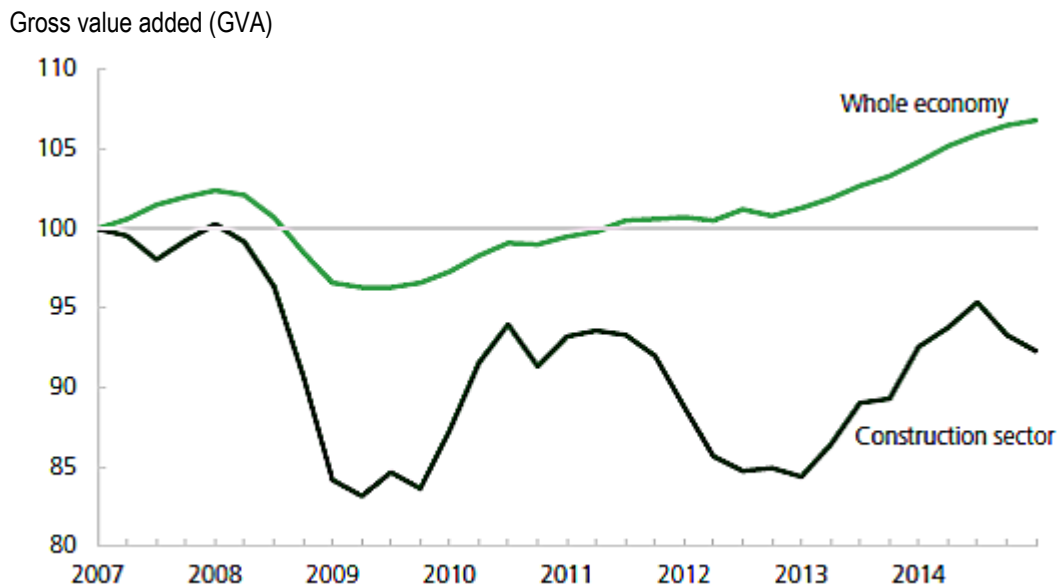


Figure 2.3: Economic Output of UK Construction Sector
Source: Office of National Statistics (2015)

Despite the challenges that the industry has faced since the 2008 economic crisis, construction continues to be one of the largest industries in the UK. The figures in Table 2.4 show that the construction industry is a key source of GVA in the UK.

In terms of employment, the industry creates jobs starting from the planning stages prior to construction and during the construction phase. As identified above, the industry employed around 2.1 million people in various roles in the third quarter of 2014. The numbers of jobs created in the UK construction industry over the last twelve years is presented in Table 2.5.

Table 2.5: Jobs Created in the UK Construction Industry

Year	Jobs Created (Millions)	% of Total Jobs
2004	2.11	6.8%
2005	2.22	7.1%
2006	2.26	7.1%
2007	2.33	7.3%
2008	2.36	7.3%
2009	2.17	6.9%
2010	2.07	6.6%
2011	2.07	6.6%
2012	2.04	6.4%
2013	2.06	6.4%
2014	2.10	6.3%

Source: Office of National Statistics (2015)

Note: The figures represent the level at the third quarter of each year.

In terms of firm size, the majority of construction firms in the UK are small and very small firms. The role of small construction firms is evident in the UK, with the majority of the firms having only up to three employees (Office of National Statistics, 2016) as depicted in Figure 2.4. These firms are defined as micro firms as they have fewer than 10 employees (BERR, 2006).

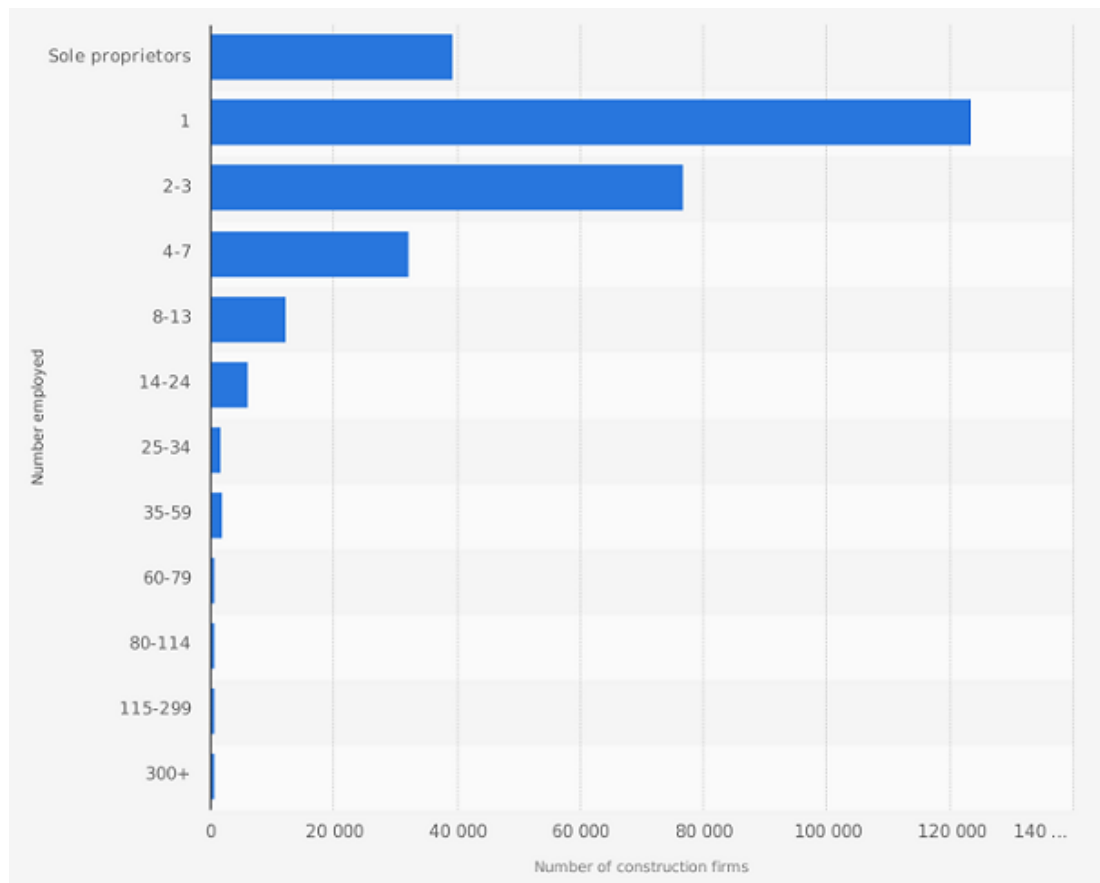


Figure 2.4: Number of Construction Firms in the UK in 2016, by Number Employed
Source: Office of National Statistics (2016)

During construction, the industry uses a huge number of suppliers for materials, equipment, technologies and plant along with many different specialist subcontractors. In addition, it creates other ancillary service areas required by particular projects such as waste skips and accommodation for workers. Thus, the construction industry represents a massive operation in the UK which makes valuable contribution to its economy.

2.7.2 Sectors within the UK Construction Industry

The construction industry encompasses a number of different sectors that are defined by the type of work undertaken for the development of structures and buildings. These sectors could be distinguished by observing the different demands of each customer group. Figure 2.5 illustrates the major sectors in the construction industry.

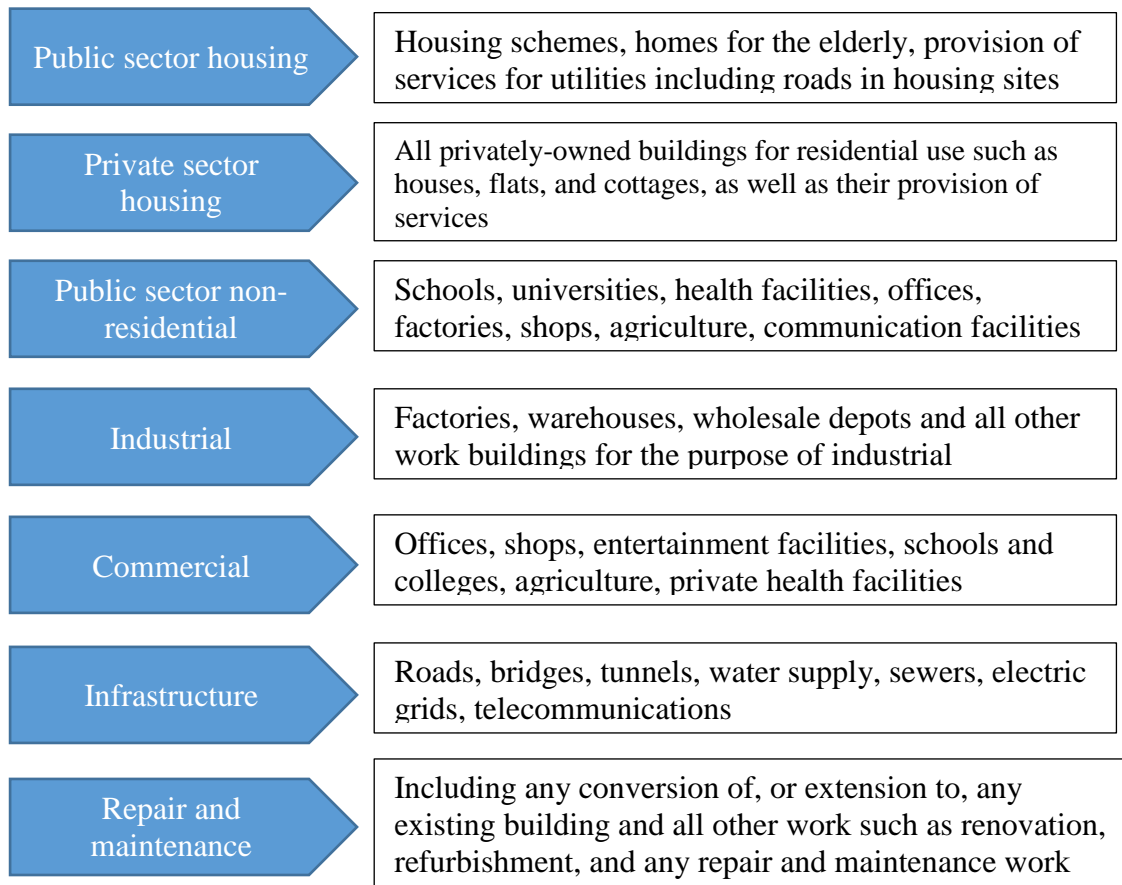


Figure 2.5: Market Segmentation in the Construction Industry
Source: MINTEL (2015)

As reported in research undertaken by a real estate company in the UK, Bilfinger GVA, the housing and commercial sectors in the UK construction industry were the main contributors to the country's economy (GVA, 2015). Along with the infrastructure sector, these three sectors were projected to drive construction output growth to 5.5% by the end of 2015, followed by 4% in 2016 (CPA, 2015).

2.7.3 The Construction Process

Construction usually involves the translation of designs into reality. Its activities are undertaken in response to demand for a construction product or constructed facilities. As construction is a project-based activity (Fellows & Seymour, 2002), it is executed within a certain period of time which bring together various resources to achieve a

specific objective (Turner, 2006). The term “project” represents the temporary activity which includes all related activities from inception to completion. It also involves input from and interactions between relevant individuals and interest groups (Newcombe, 2003). This coalition is necessary due to extensive fragmentation and specialisation within any particular construction project. Normally, the project brings together capital, various specialisations, the workforce and other resources required for the realisation of the intended facility.

In general, the participants that are directly involved in a particular construction project consist of architects, engineers, consultants, contractors, construction workers, and clients who spend their money on the project. Among others, material and equipment suppliers and manufacturers, land developers, real estate brokers, building finance and insurance agencies are also part of the construction ‘landscape’ but they are generally considered as separate from and ancillary to the construction industry as a whole (Clements & Gido, 2012). To a certain extent, the government interacts with the industry as financier, regulator and purchaser (Isa et al., 2013). The whole construction process relies on the input of these participants and requires them to work with each other while carrying out their own functions in order to complete a project successfully.

Under the traditional system³ implemented within the construction industry, the construction process starts with the formation of a design team which is commonly appointed by the property owner or client. The design team typically includes a number of the actors identified above, as well as others: architects, quantity surveyors, structural engineers, mechanical and electrical engineers, and planning supervisors. This team would prepare the design which comprises drawings and specifications for the project. Once the design is completed, a number of construction companies will bid for the work. Upon evaluation of these bids, the contract is normally awarded to the most cost-efficient bidder, who will build the facilities and perform required works as per the contract. As the project team leader, the architects are involved all the way

³ Traditional system also known as design-bid-build method (Lim & Mohamed, 1999).

through the construction process until the building is ready to be occupied. This process is illustrated in Figure 2.6.

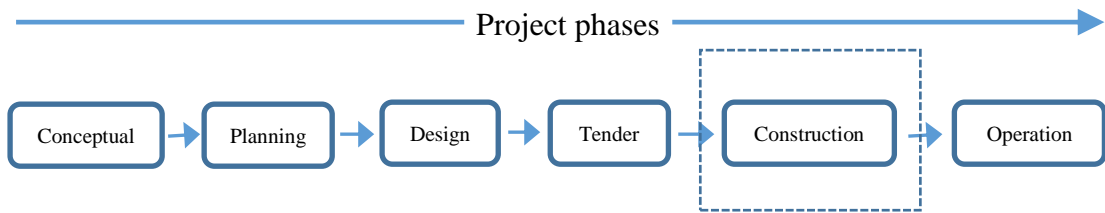


Figure 2.6: The Traditional Process of a Construction Project
Source: Lim and Mohamed (1999)

As elaborated in several studies, a construction project typically involves a number of phases: conception, planning, design, tender, construction and operation (Ahadzie, Proverbs, Olomolaiye, & Gameson, 2006; Lim & Mohamed, 1999; Takim, Akintoye, & Kelly, 2003) . The construction phase tends to be the focus for the overall success of the project (Ahadzie et al., 2006) since it is the phase where the project goals such as cost, time, quality and safety are tested (Lim & Mohamed, 1999). Accordingly, the discussions surrounding the research questions for the current study also revolve around this phase.

2.7.4 The Participants in the Construction Project

The main participants of a construction project are the clients who are the initiator of the project, the multi-disciplinary construction consultants who are appointed by the clients to execute the project, and the building contractors who are responsible to construct the building. These participants would work together to manage and carry out the distinct but interrelated activities of the construction process from the beginning to the end. The complexity of a construction project calls for inputs from architects, quantity surveyors, engineers and contractors for the production of the intended facilities. The flow of each participant's involvement in a construction project is illustrated in Figure 2.7.

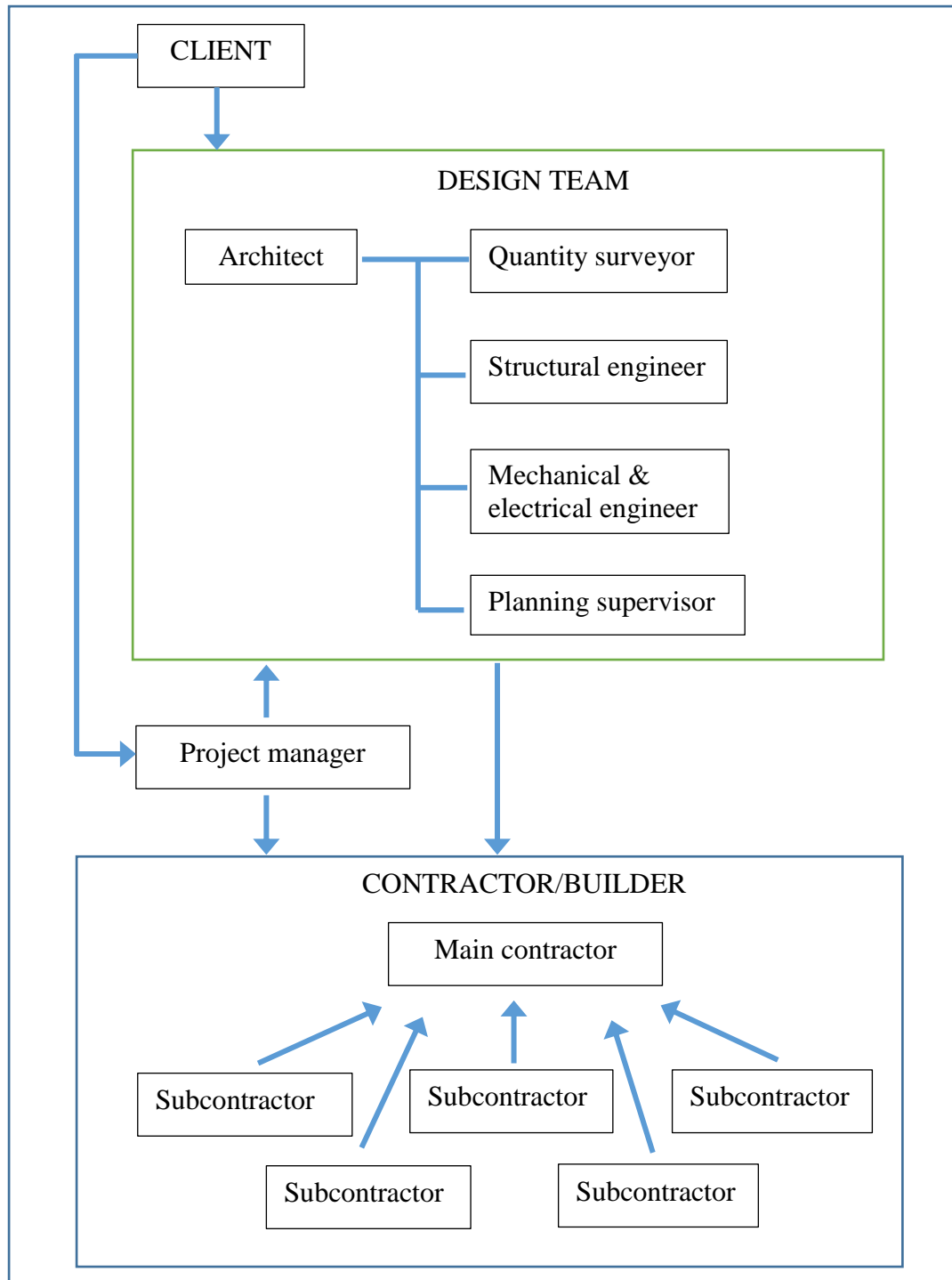


Figure 2.7: General Construction Project Participants
Source: Developed by the author.

2.7.4.1 The Client

The client is the key to the initiation of a construction project which starts with the client recognising a need for a construction product. The client is the individual/body that would raise the necessary financial resources for the creation of the required facilities. Various construction professionals would be commissioned by the client to build particular requirements. The client will be involved directly and indirectly during the design and construction phases until the completion of the project when the facilities are delivered to them. The facilities would then be under the full responsibility of the client, who can choose whether to sell them in the marketplace or to take their ownership.

According to Pinto (2016), the client of a construction project can be classified to be from the public sector or private sector. Public sector clients are public authorities operating under the Acts of Parliament; their capital building programmes and expenditures are often controlled by the central government. The public sector clients for the UK construction industry comprise central government departments, local authorities, health authorities, and public corporations. On the other hand, the private sector clients are private companies or individuals that build facilities for sale, lease, rent or their own occupation. They may be involved in any construction project based on their own requirement and budget, with limited control from local/central government in terms of planning and consent for development. Examples of private sector clients for the construction industry are multi-national companies, national companies, local property development companies and private clients.

2.7.4.2 The Design Team

The design stage of a proposed construction project is vital, especially during the initial construction process where the architectural design and details among structural, mechanical, and electrical engineers have to be well integrated, whilst coordinating with the economic implications and costs. The architect normally acts as the design team leader who is responsible for design integration and project coordination. The other team members also play important roles in contributing to the project.

Traditionally, the architect is a professionally qualified person who is responsible for the design function. His/her role is to interpret the client's requirements into a specific design that incorporates its appearance, structure, proportion, function and cost (Kloppenborg, 2012). In addition, the architect is responsible for obtaining planning permission for the design. Normally, the architect is heavily involved throughout the whole construction process, and he/she organises the entire construction process, starting from consulting the client and ending with the commissioning of the facilities (Clements & Gido, 2012). As the architect is directly involved in almost all stages of the construction process, he/she must possess the essential design skills, comprehensive understanding of construction materials, ability to communicate and coordinate, and ability to design within a set budget (Pinto, 2016).

In contrast, the quantity surveyor is responsible for evaluating the economic and financial implications of a construction project (Blankenbaker, 2013). He/she could provide professional advice to the architect or client on matters relating to the cost of a proposed construction project. His/her role is very important as cost is a fundamental factor influencing the decision to undertake a construction project. Therefore, cost is discussed during the earliest stage in order to advise the architect and client accordingly.

The structural engineer functions as an advisor to the architect on all structural matters such as the suitability of the proposed materials, stability of the structure, structural feasibility and appropriate size for a construction project (Blankenbaker, 2013). He/she works together with the architect to prepare a structural design for the proposed construction project and submits the structural calculation to the local authority for approval.

Furthermore, the mechanical and electrical engineers, who are also known as services engineers, contribute to the design stage of a construction project by ensuring that the visual and thermal comforts of a particular building are achieved (Allen & Iano, 2013). Initially, they would analyse the client's requirement and then advise the architect on the most appropriate design solution. If any structural problem occurs due to the design

prepared by the services engineers, the structural engineer would step in to solve the issue.

Generally, the planning supervisor plays an essential role in handling the health and safety issues of a construction project. In non-domestic project⁴, this position is normally appointed by the client. The planning supervisor is part of the design team, and he/she has to co-ordinate the health and safety aspects of the initial planning and project design stages. This includes ensuring the designers' cooperation to consider health and safety aspects in their design and compliance to their duties related to health and safety (Spence & Kultermann, 2010). In addition, the planning supervisor has to ensure a health and safety plan is prepared during the pre-tender stage as it is needed for the tendering process.

During the design process there are various opportunities for green dimensions to be considered and incorporated into the project design connected to, for examples, materials, services and utilities.

2.7.4.3 The Contractor/Builder

The contractor performs the construction works according to the plans and specifications provided by the client. Specifically, the main contractor is fully responsible for the completion of the project. As stated by Pinto (2016), the main contractor is the key representative of project participants who are constructing the building. During construction, they might subcontract out a substantial part of the work but would maintain overall control of the project through placement of project managers and onsite supervision. The subcontractors are responsible for their specialised works or package of service, such as electrical works, windows, plastering, plumbing or flooring.

⁴ Non-domestic projects are commercial projects.

McCoy, Thabet, and Badinelli (2009) explained that the contractors/builders are individuals or firms who are directly involved in construction activities, and deal with the major processes of a construction project. To some extent, the output of their works, would affect the performance of a particular construction project. The tasks and duties of the contractors begin once they are awarded a particular tender or contract for a construction project. These contractors carry their significant responsibility to construct a building according to the specified design and specifications. They are also responsible for controlling their sub-contractors, employed operatives, suppliers, materials and plant in order to the execute the project successfully based on the specified cost and schedule (Kloppenborg, 2012). Additionally, the contractors have to coordinate the efforts of all workers as they need to ensure that the completed works satisfy the architect and client, as well as comply with the contract specification and requirements of planning authorities.

2.7.4.4 The Project Manager

Generally, the project manager is the client's agent or main representative. The project manager does not perform any construction work on the projects but he/she acts as liaison among the client, the design team and the contractor. His/her main role is to coordinate the construction project according to the contract (Pinto, 2016). Occasionally, the architect also acts as the project manager; however, a separate project manager is normally appointed for very large projects.

2.7.5 Environmental Issues in the Construction Industry

Construction of any types of building, whether residential, commercial or other infrastructure has significant impact on the environment. Every aspect of building and infrastructure development could affect the environment, in which many activities can result in negative environmental consequences. The construction industry plays a substantial role in increasing the quality of life by providing housing, utilities, workspaces and transport infrastructure. It also makes significant contribution to the

economy, despite its serious consequences on the environment (Burgan & Sansom, 2006). Both the processes of building new facilities and renovating existing built environment have various environmental impacts, which are illustrated in Figure 2.8. Construction is directly and indirectly responsible for the emission of greenhouse gases as a result of the energy used for its activities, such as raw material extraction, construction, transportation and demolition (Sorrell, 2003).

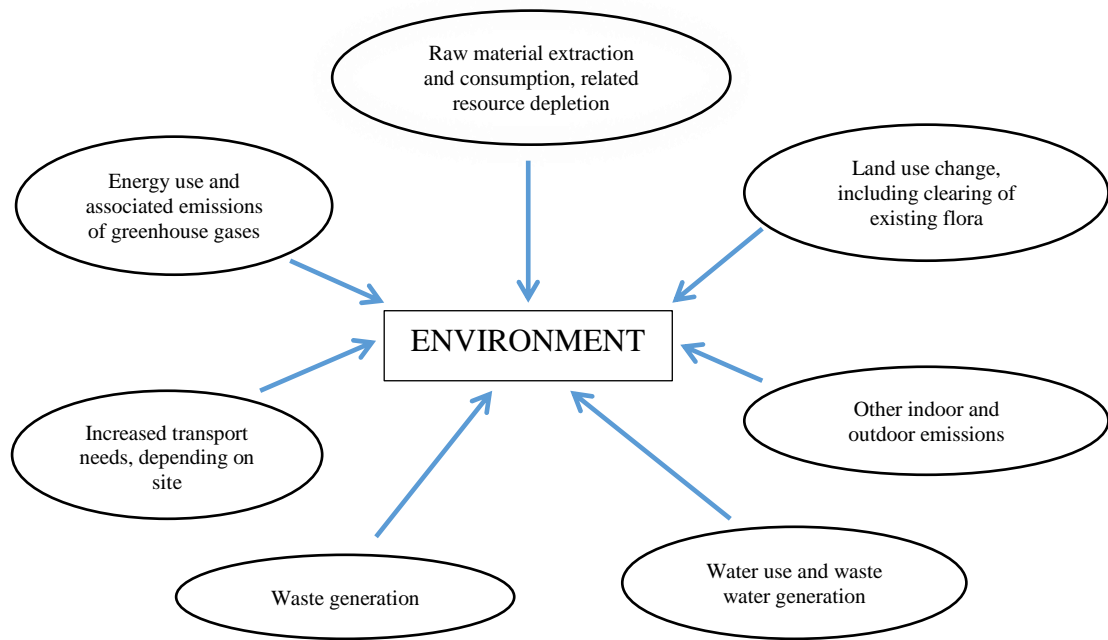


Figure 2.8: Main Impacts of Construction Industry and Buildings
Source: Sev (2009)

Around the globe, there has been growing concern regarding the environmental impacts created by the construction industry. In the UK, around 420 million tonnes of construction materials are consumed by the construction industry each year, which is equivalent to 7 tonnes per person. However, approximately 120 million tonnes were wasted out of the total consumption of all materials (EISC, 2012). Construction waste accounted for 32 % of total landfill waste, and this shows how it contributes significantly to landfill (Environment Agency, 2010). In addition, Construction Excellence (2008) reported that up to 13% of the ‘waste’ was not delivered nor used.

In 2013, total UK greenhouse gas emissions were equivalent to 566 million tonnes of carbon dioxide (DECC, 2015), of which the construction sector contributed 11.2% of these emissions (Office of National Statistics, 2015). In addition to direct environmental impacts caused by its activities, the industry is responsible for significant amounts of soil, air and water pollution. BIS (2010) reported that almost a third of all industry-related pollution incidents occurred in the construction industry. This situation needs to be addressed if the industry is to reduce its negative impact on the environment.

The industry's economic significance creates opportunities as well as responsibilities for the construction sector to innovate and advance beyond its existing practices. This requires the industry to adopt different thinking and new ways to perform its operations. The industry players also need to acquire new knowledge and skills, along with the appropriate ways to exploit them.

2.8 Green Innovation Practices in the Construction Industry

Green innovation practices in the construction industry require the participants who are involved in construction activities to increase their effort towards minimising the environmental impact related to their operations. These efforts can be promoted by planning and managing the construction activities, through attempts to improve the efficiency of the processes; conserve energy, water, and other resources; and minimise the amount of construction waste. In addition, the efforts include other strategies that do not have substantial impact on the project budget or schedule, but may reduce costs and increase productivity in certain condition (Qi et al., 2010). Hence, the adoption of green innovation practices in the construction industry can be viewed as a strategy that mainly concentrates on improving the efficiency of resource usage while protecting the environment.

Many researchers and practitioners agree that innovation is the prerequisite for competitive advantage (Egbu, 2004). Previous research on construction projects which was focused on innovation in the field of sustainability demonstrated that increased

corporate focus on green innovation improves the quality of the construction projects; sustains and fortifies the company's position in the market; and improves and strengthens the cooperation among the participants involved (Bossink, 2004). Furthermore, Cole (2000) contended that environmental responsibility demonstrated by construction firms offers many potential advantages such as better opportunities to tender, less money wasted on fines, less money lost through wasted resources, less money lost on restoring environmental damage, and enhanced environmental profile.

Previous studies have shown that a number of construction companies have pursued the protection of the environment during project implementation. For example, a case study conducted by the Building Research Establishment (BRE) (1998) highlighted the implementation of environmental practices by a UK house builder, Rydon Construction. The leading house builder had engaged in a number of environmental practices such as creating environmental awareness, identifying site storage when arranging site layouts, optimising the storage and protection of materials to minimise waste, using waste face bricks for non-facing applications, using recycled materials instead of purchasing primary materials, and separating and sending timber, metal and paper waste for recycling. These practices were proven to assist the company in maintaining the environment and its valuable resources.

The application of green innovation practices is not limited to the construction industry; in fact, all business activities are now related to these practices. Improvements in environmental performance may contribute to a firm's competitiveness. Therefore, firms should consider being engaged in green innovation in order to strengthen their competitiveness. However, involvement in green innovation practices requires manipulation of knowledge within the organisation and acquisition of knowledge from external sources. Thus, this study seeks to provide better understanding regarding the role of firm's capability, particularly its absorptive capacity, in acquiring and assimilating relevant knowledge. Notably, this approach is practical for firms to fully utilise the existing and available knowledge in cultivating and realising their intention to be involved in green innovation practices.

2.9 Hypothesis Development

This study models the relationship between absorptive capacity and the adoption of green innovation practices among construction companies. Management theorists have suggested that fundamental prerequisites for the adoption of innovations are the acquisition, processing and assimilation of information into organisational knowledge. As already discussed, this learning capability is described as absorptive capacity by Cohen and Levinthal, (1990) and is suggested as a key resource to support the adoption of innovation (Dewar & Dutton, 1986; Fichman, 2001).

Sambamurthy and Zmud (1999) claimed that absorptive capacity is a critical factor that contributes to an organisation's innovativeness. This is in line with work conducted by Ramamurthy, Sen and Sinha (2008) which revealed that absorptive capacity is one of the key determinants for the adoption of information technology innovation. Development of absorptive capacity requires organisational capability that improves the firm's ability to learn. This research identifies three organisational capabilities that can enhance the development of absorptive capacity, namely existing knowledge utilisation, knowledge building, and external knowledge acquisition.

2.9.1 Existing Knowledge Utilisation

Utilisation of existing knowledge is determined by the firm's existing knowledge that is reflected by its employees' individual skills and experiences, prior relevant knowledge, and communication climate. The basic assumption by Cohen and Levinthal (1990) is that prior knowledge facilitates the usage of new knowledge and, therefore, determines a firm's level of absorptive capacity. This cumulative nature of knowledge reflects the path-dependent nature of absorptive capacity, which is influenced by the contribution of past experiences to organisational memory (Zahra & George, 2002).

Initially explored by Cohen and Levinthal (1990), this path-dependent nature of absorptive capacity was also highlighted in the capability-based reconceptualisation

of the theory of absorptive capacity by Zahra and George (2002). Consequently, Teece (2007) claimed that the importance of prior knowledge increases in dynamic conditions because a wide knowledge base helps firms to access additional development paths. Nevertheless, prior knowledge is more likely to be developed and maintained when the new knowledge that the firm wants to exploit is closely related to its current knowledge base. This is supported by Nonaka and Takeuchi (1995), who stated that a firm requires previous knowledge that is closely related to the new information in order to facilitate the assimilation and application of that new knowledge. Prior knowledge influences both the cost of discovering and acquiring new knowledge and the degree to which one is likely to engage in a search for new practices or innovation (Cohen & Levinthal, 1990), including green innovation.

In addition, a firm's absorptive capacity depends on its existing stock of knowledge, much of which is embedded in its products, processes and people. Kim (1999) stated that one of the important elements underlying the absorptive capacity framework is the existing knowledge base. In particular, the existing knowledge base of a firm is strongly related to its employees. Thus, employees' individual skills and experiences are crucial in understanding and evaluating a firm's existing knowledge base. Vega-Jorado, Gutierrez-Garcia and Fernandez-de-Lucio (2008) defined individual skills as the employees' level of education and training, as well as their experiences in certain knowledge fields that are obtained over time. This is in line with the view of Gray (2006) who claimed that the degree of functional knowledge in a firm is related to the levels of formal training, education, and experience of its employees, as well as their source for knowledge acquisition. Thus, higher educational attainment among employees suggests a stronger foundation of prior knowledge within a firm.

Moreover, Rothwell and Dodgson (1991) indicated that firms need sufficient qualified scientists, engineers and technical specialists to access knowledge outside of their organisations' boundaries. Considering this factor, Frenz, Michie, and Oughton (2004) included the proportion of engineers and scientists as a share of total employees for their analysis. In their study Minbaeva, Pedersen, Bjorkman, Fey and Park (2003) tested this relationship and verified that the employees' ability in terms of their educational background is an important aspect of a firm's absorptive capacity.

Additionally, Daghfous (2004) stated that employees with higher levels of education and qualifications in a particular area usually have higher levels of ability to absorb new knowledge in that field. Highly educated and technically qualified employees are generally more receptive to assimilate and transform available external knowledge in order to exploit their knowledge and expertise (Vinding, 2006). In other words, firms that have highly educated and trained employees will have higher levels of absorptive capacity.

It has also been argued that the education of employees is an important attribute to a firm and represents one of its key innovation resources. Employees who are well-educated are more likely to open their mind and read extensively, increasing their awareness on information or issues beyond their employment boundary. Blundell, Dearden, Meghir and Sianesi (1999) claimed that well-educated employees are more likely to travel often, join professional associations, seek out career advancement and work towards firm improvement. Therefore, firms with such employees tend to develop a conducive environment for knowledge within their firms. The strong existing knowledge base that is derived from employees' skill and experience could be considered as a valuable firm capability. If such capabilities already exist, they could facilitate the green innovation adoption process (Darnall & Edwards, 2006).

Furthermore, a firm's absorptive capacity also depends on its ability to stimulate and manage knowledge sharing across departments, functions, and individuals. This factor of a firm's communication climate has been addressed in a number of studies. For instance, Van den Bosch, Volberda and de Boer (1999) discovered that the absorptive capacity of a firm is determined by its expertise in stimulating and managing knowledge sharing. This aspect is closely related to organisational culture and the organisation of knowledge flows.

Firms require full commitment from the upper management to create a learning culture in their organisation. As organisational culture has a significant influence on a firm's innovativeness, a culture that supports participation, knowledge sharing and openness to change should be considered in the development of absorptive capacity. This can be realised, primarily, by encouraging cross-functional communication which has

been found to improve absorptive capacity through enhancing knowledge sharing amongst departments and individuals in a firm (Daghfous, 2004; Van den Bosch et al., 1999). The existence of this type of knowledge culture within an organisation has a significant influence on a firm's innovativeness, in particular, facilitating the adoption of green innovation.

The rationale put forward by Davenport, De Long and Beers (1998) stated that, a 'knowledge-friendly' culture is essential in order to gain and use knowledge effectively within the organisation. These researchers argued that organisational culture should incorporate several elements related to knowledge. For instance, the employees must be encouraged to have a positive orientation to knowledge by being intellectually curious, willing and free to explore, and encouraged to create and use knowledge. More importantly, the employees are not inhibited in sharing knowledge. In addition, employees have to be given full support to suggest any improvement or change that will lead to enrichment of knowledge through initiatives such as brainstorming for new ideas or identifying and solving shared problems (Schmidt, 2005). Albers and Brewer (2003) outlined that promotion of knowledge transfer requires firms to provide their employees with a certain amount of autonomy and encourage diversity of opinions. In turn, this will provide direction to a firm to be engaged in any type of innovation activity, including green-related innovation.

The above discussion on the presence of firms' prior knowledge, existing knowledge stock and knowledge-friendly culture within organisations, which reflects the first dimension of absorptive capacity, that is, Existing Knowledge Utilisation, could be considered as one of the pre-requisites in facilitating the firms to be engaged in green innovation, particularly in green technical, process and administrative innovation.

Accordingly, the following hypotheses are proposed for the current research:

H1a: A higher level of a firm's existing knowledge utilisation is positively related to the adoption of green technical innovation.

H1b: A higher level of a firm's existing knowledge utilisation is positively related to the adoption of green process innovation.

H1c: A higher level of a firm's existing knowledge utilisation is positively related to the adoption of green administrative innovation.

2.9.2 Knowledge Building

Successful implementation of green practices in a firm requires education and training for its employees. By participating in training, employees become more responsive to the need for quality and environmental control, as well as more adaptable to change. They are also more likely to change towards proactive attitudes (Wong, 1998). Employees' participation in specific training efforts related to environmental issues may realise certain benefits for firms such as compliance with regulatory requirements, positive public image, encouragement to employees to become stewards of the environment, and motivation to employees to participate in proactive environmental management (Cook & Seith, 1992).

In addition, knowledge sources could only be accessed through the exploitation of the human capital of a firm. Juceviciene and Ceseviciute (2009) claimed that the key factors for innovation are the promotion of human capital and creativity. In order to achieve these factors, the supporting managerial conditions and education have to be created through learning (Janiunaite, 2008). Moreover, Kim (1998) identified the intensity of effort to increase prior knowledge as one of the key factors in developing a firm's absorptive capacity. Training and education of employees aimed at enriching and improving their relevant knowledge contribute to better absorptive capacity for both individuals and the wider organisation.

Apart from that, Mangematin and Nesta (1999) claimed that training and education increase the stock of knowledge in an organisation. The acquisition of relevant knowledge through learning accelerates the capability of individuals and teams to assimilate more new knowledge. Consequently, this facilitates the development of innovative processes or products (Cohen & Levinthal, 1990). Several studies found that firms with a higher percentage of environmentally-trained employees tend to have higher capacity to adapt to new environmental requirements (Hart, 1995; Klassen & McLaughlin, 1993; Zilahy, 2004). Also, a study by Murovec and Prodan (2009)

posited the positive relationship between the organisation's investment in training and the level of absorptive capacity.

Therefore, greater levels of absorptive capacity within the firm may be achieved by providing relevant knowledge to employees through training and education. Notably, this capability is essential to facilitate the firm's engagement in green innovation, particularly in green technical, green process and green administrative practices. Hence, this research hypothesises:

H2a: A higher level of a firm's knowledge building effort is positively related to the adoption of green technical innovation.

H2b: A higher level of a firm's knowledge building effort is positively related to the adoption of green process innovation.

H2c: A higher level of a firm's knowledge building effort is positively related to the adoption of green administrative innovation.

2.9.3 External Knowledge Acquisition

The balance between a firm's concentration on its existing knowledge and its openness towards knowledge sharing is supposed to encourage innovation (Deephouse, 1999), and enhance innovative performance (Caloghirou et al., 2004). An existing knowledge base is essential, but not sufficient to perform innovation effectively, and thus, firms cannot rely solely on existing knowledge. Caloghirou et al., (2004) claimed that the openness of a firm to external knowledge sources is another important element when evaluating its potential for innovation. Internal efforts of a firm to obtain ideas from external sources will strengthen existing knowledge and consequently, facilitate the generation of new types of knowledge. Due to this need for knowledge, many firms have established scanning mechanisms to identify external sources of knowledge (Cohen & Levinthal, 1990; Elenkov, 1997).

According to Kastelli, Caloghirou and Ioannides (2004), a firm that intends to enhance its absorptive capacity, has to build the capability to interact with other actors and access external sources of knowledge. Globalisation, increasing challenges from the

emerging knowledge economy, growing competition, and rapid technology change have affected firms which now cannot rely only on their own capabilities and knowledge base; they also need to leverage the experiences and knowledge of other economic actors. Therefore, firms have to establish their external communication channels and knowledge flows.

Openness to external sources of knowledge is an attitude that was claimed to be a significant contributor to the introduction of new practices or innovative effort (Mol & Birkinshaw, 2009). Potentially, such an attitude can take many forms. For example, managers or employees can bring in new ideas to the firm from their own previous experiences that were gained outside of the firm. Another form of such attitude is reflected in reading the environmental or innovation literature to get input regarding new practices that can be implemented. In addition, Souitaris (2001) stated that firms can access external sources of knowledge by scanning external information which can be obtained from sources such as research databases, journals and conferences. Kang and Kang (2009) added that professional magazines, fairs or exhibitions, and media such as newspapers and television can also provide the appropriate information to enhance the firm's knowledge base.

The usage of external sources of information contributes "raw" informational resources to be processed within the organisation (Knudsen & Roman, 2004). This information flow can assist an organisation to identify its deficiencies and promote the perception towards a need for change or improvement (Pierce & Delbecq, 1977). Consequently, this information can be used by key decision makers in facilitating decision making about the adoption of innovation and analysing the innovation's function in addressing various environmental issues. Furthermore, by gaining access to various knowledge sources, a firm can increase its chances to discover useful information. Leiponen and Helfat (2010) claimed that access to wider knowledge sources increases a firm's chances of gaining access to complementary knowledge.

In addition to firms' internal efforts to obtain ideas for innovation from external sources, it is important for firms to create links with outside entities as well in order to discover and develop new solutions and acquire new knowledge. The nature of

innovation, which is specific and often idiosyncratic to a certain degree, complicates knowledge acquisition and transfer from one organisation to another. Therefore, formal or informal linkages outside of the organisation have to be established in order to facilitate the process of knowledge acquisition and transfer. The effort to establish external linkages refers to cooperation with other actors within or outside of the industry, such as other firms, suppliers, customers and universities or research institutes. This type of cooperation can be realised by engaging in informal relationships or formal relationships like partnerships or joint ventures.

Previous studies suggest that external linkages or networks are important paths in obtaining information and knowledge, and accomplishing building capabilities (Ahuja, 2000; Sparrowe, Liden, Wayne, & Kraimer, 2001). Studies of firm behaviour indicate a trend towards focussing on the roles of interactions, networks and relationships in shaping innovation effort. For example, Shan, Walker and Kogut (1994), revealed a link between cooperation and innovative output in start-up firms within the biotechnology industry. Moreover, Powell, Koput and Smith-Doerr (1996) assessed the contribution of inter-organisational collaboration, and discovered that the benefits gained from networks or collaborations lead to greater innovative performance. All of these studies stressed the importance of a firm's external linkages in facilitating their efforts towards innovative opportunities.

These viewpoints are consistent with Hordern et al.'s (2008) claim that engagement in such relationships facilitates a firm in benefitting from external knowledge. Firms can learn and exploit external knowledge through linkages or networks. In order to introduce a specific innovation, like green innovation, a firm requires the capability to translate external information input into the development of the innovation. Traditionally, this capability was associated with the presence of absorptive capacity (Cohen & Levinthal, 1990) which can be obtained from interacting with particular actors through informal or formal linkages (Freitas, Clausen, Fontana, & Verspagen, 2011).

Kang and Kang (2009) emphasised the importance of informal relationships as one of the methods to gain external knowledge. Knowledge transfer from informal

relationships does not require formal agreements between the focal firm and the external knowledge sources (Pyka, 1997). Furthermore, the properties of such knowledge transfer resemble that within a social network, which does not involve high transactional, managerial, and maintenance costs (Kang & Kang, 2009). The advantages encourage firms to develop more informal relationships in their effort to access external knowledge easily and build innovative capabilities.

Furthermore, interest in the construction industry has grown regarding the possibility that partnering can facilitate knowledge transfer among firms. Partnering can be categorised as a formal relationship, with its emphasis on communication, reward sharing, and the development of trust among organisations, which can assist the management of knowledge flows and innovation within the organisation. Typically, both formal and informal relationships can be established with the suppliers, customers, competitors, environmental organisations, knowledge leaders, and industry associations that possess the relevant knowledge for enriching a firm's knowledge base. From the perspective of the construction industry, numerous industry participants can potentially act as producers or repositories of knowledge that actively disseminate the relevant knowledge, such as professional institutions, universities, construction research bodies, as well as individual academicians and researchers (Gann, 2001).

A number of studies have shown that suppliers could be a useful source for gaining innovative ideas. Suppliers often interact with a range of customers within particular industries and this increases their experience and access to a broad range of information. In their study, Geffen and Rothenberg (2000) revealed the benefit of collaboration with suppliers in the production process for three US assembly plants. They claimed that a close relationship between buyer and supplier increased the supplier's knowledge on the buyer's operations and needs. This invaluable information facilitated the automobile manufacturers to implement successfully innovative environmental technologies. In addition, suppliers with better knowledge on the environment can contribute to their buyers' environmental innovative efforts.

In turn, customers could provide their green-related requirements and specifications to be addressed by the focal firm to fulfil their needs. Customers have a prominent influence on the offerings of particular firms. In recent years, focal firms have increasingly been under pressure from customers to help fulfil their environmental considerations. Customers have become more environmentally-oriented and this has resulted in increasing demand for information about the environmental impacts of materials and products that are offered by a focal firm. Customers want to know the origin of a product, its distribution process, and its ecological impact. At the same time, they provide their own environmental requirements and information to be followed by the focal firm. This can lead to the adoption of new practices in the firm.

Compared to collaboration with other supply chain members, collaboration with competitors is more informal and can be considered as invisible (Bengtsson & Kock, 1999). Traditional notions state that, logically, there is no cooperation among competitors (Bengtsson & Kock, 1999): nonetheless, a number of studies highlight the efforts of certain firms to become more competitive by sharing some useful resources with their competitors (de Faria, Lima, & Santos, 2010). As argued by Yarahmadi and Higgins (2012), an eco-advantage of a competitor can influence the competitive playing field. Occasionally, competitors work together to avoid competitive disadvantages arising from environmental issues (Azzone & Noci, 1998).

In addition, a number of other studies demonstrate the benefits of partnering with other firms or competitors. For example, a study by Barlow (2000) on innovation and learning in offshore construction projects, found that the partnering approach with other firms produced very significant performance gains compared with similar offshore developments that were traditionally procured and managed. The approach also resulted in technical and process innovation. Tsai (2009) also stresses that cooperation with competitors enhance firms' capabilities and knowledge on environmental innovation. Moreover, Blayse and Manley (2004) emphasised that strong industry relationships are required to maximise innovation opportunities as these relationships have a significant influence on construction innovation (Dubois & Gadde, 2002; Miozzo & Dewick, 2002).

On the other hand, the role of environmental organisations is becoming more important to most companies in facilitating their efforts towards implementing environmental activities. Nowadays, environmental organisations that are normally operated by nongovernmental organisations (NGOs) have more power and have expanded the scope of their activities. In terms of environmental issues, they are trying to contribute at local, national and international levels by becoming active partners that can greatly influence a firm's environmental performance (Horbach, 2008).

In addition, environmental organisations have voluntarily become facilitators by providing information to assist firms in being alert to environmental issues. They offer consultation services on how to become more environmentally-oriented or greener. Thus, firms can easily obtain ideas as well as expertise by working with particular environmental organisations that have specialised knowledge in their respective areas of interest (Bendell, 2000). Relationships with these parties may potentially increase a firm's ability to enrich its information and knowledge for environmental improvement.

There are a number of examples of successful collaboration between businesses and environmental organisations. For instance, the collaboration between McDonalds and the Environment Defence Fund (EDF) improved the image of McDonalds, as well as lowered the company's cost through the shift from using polystyrene clamshells to quilted paper wrappers (Stafford & Hartman, 1996). The collaboration between the World Wildlife Fund (WWF) and Coca-Cola is another example of successful collaboration. They worked on preserving the priority river basins, as well as introducing environmental innovations into Coca-Cola's products and practices (Matthews, 2011). As environmental organisations have advanced, they are able to organise campaigns, provide a lot of information about environmental issues, and use their power to stop the progress of particular projects that are hazardous to the environment (Bendell, 2000).

Formal relationships with knowledge leaders such as universities and research institutes can assist firms to build capabilities and obtain rare resources (Belderbos, Carree, & Lokshin, 2006). Interaction with universities and research institutes assists firms to stay updated on current issues, especially environmental matters (Mohannak,

2007; Nieto & Santamaria, 2010; Zeng, Xie, & Tam, 2010). Normally, this type of cooperation revolves around research and development efforts which provide firms with sources of new and innovative ideas. Lehmann, Christensen and Johnson (2010) examined the role of universities in cooperative networks with two Danish firms. Their research finding revealed that universities contribute to sustainable innovation by offering their expertise as knowledge leaders to provide a lot of information, ranging from research output to more applied information, such as technology transfer.

As the main role of universities is to train and educate people to become experts for their future careers, they are not able to become completely involved in environmental initiatives. On the contrary, research centres have the ability to focus on environmental issues and allocate more resources for environmental activities. Thus, they can provide a variety of information related to particular environmental issues which can also lead to the discovery of environmental solutions. A study conducted by Azzone and Noci (1998) reported a successful collaboration between an Italian car manufacturer – Fiat Group – with a number of external research centres. The collaboration had resulted in improved recycling process through the removal of polyurethane from their car bumpers.

The number of industry associations around the world has increased in recent years. These industry associations are established to protect the interests of particular firms by lobbying their members' interests continuously at both local and national levels. Generally, industry associations offer a wide range of relevant business services to particular industries such as providing professional advice, giving support, and organising educational programmes for their members. Notably, industry associations are a substantial source of knowledge.

Implementation of environmental innovation solutions may be hindered by factors such as high costs and high risk of failure. However, collaboration with industry associations may overcome these problems. Industry associations provide a platform for their members to apply for funds through their strong ties with government agencies and other public or non-public organisations. In addition, an industry association is responsible for helping its members to improve by preparing a platform

for them to interact and cooperate with each other on particular issues, including the environmental agenda.

Therefore, this study argues that absorptive capacity in the form of collaboration with suppliers, customers, competitors, environmental organisations, universities, research institutes, and industry associations is important to facilitate the firm's engagement in green technical, green process and green administrative practices, in particular. Thus, the following hypotheses are derived:

H3a: A higher level of a firm's external knowledge acquisition is positively related to the adoption of green technical innovation.

H3b: A higher level of a firm's external knowledge acquisition is positively related to the adoption of green process innovation.

H3c: A higher level of a firm's external knowledge acquisition is positively related to the adoption of green administrative innovation.

2.9.4 The Moderating Effect of Environmental Requirements

A firm's innovation processes are embedded in an environmental context (Jansen, Van den Bosch & Volberda, 2006; Levinthal & March, 1993), including requirements from the market and regulator. On the other hand, environmental requirements are important to analyse the effect of absorptive capacity because the presence of such requirements from customers and regulators imply different valuation of firm capabilities (Eisenhardt & Martin, 2000). Therefore, the impact of absorptive capacity may substantially differ according to the level of environmental requirements, however, these boundary conditions have been relatively neglected in prior absorptive capacity research (Lichtenthaler, 2009). This limited attention is remarkable, because firms often acquire new knowledge, specifically to respond to pressure or requirements from the environments, and this strategic action underscores the importance of environmental requirement influences (Cassiman & Veugelers, 2006).

By looking at the relationship between absorptive capacity and green innovation, even though several studies showed that the firms' absorptive capacity contributes to the adoption of environmental or green innovation, not all studies have shown this to be true. Research has examined the relationship between absorptive capacity and the firm's performance and innovation (Chen, Lin & Chang, 2009; Fosfuri & Tribó, 2008; Kostopoulos, Papalexandris, Papachroni & Ioannou, 2011; Zahra & Hayton, 2008). Based on empirical findings regarding the relationship between absorptive capacity and innovation and performance, there are inconsistencies that need addressing. Some empirical studies found a positive, high or low relationship (Chang, Gong & Peng, 2012; Liao, Tu & Marsillac, 2010; Song, 2015), while other studies found a negative relationship (Larrañeta, González & Aguilar, 2016; Park & Rhee, 2012).

The reason for the variation in these findings may be due to the different degree of firms' absorptive capacity. This diversity is also represented in the presence of pressure that organisations face, particularly from customers and regulators. Dynamic capabilities logic suggests that the need for new knowledge is particularly high in environments with the presence of pressure from the outside of the firm (Teece, 2007). As a consequence, firms have to rely on new and properly utilise existing knowledge to arrive at innovations which are accelerated by pressure from customers and regulators (Droge et al, 2008; Jansen et al., 2006). Thus, this study argues that regulatory and customer pressure may play an important moderating role on the relationship between firms' absorptive capacity and green innovation adoption.

On the other hand, a great number of previous studies have highlighted the influence of customer and regulatory requirement on the firms' involvement in environmental innovation (Beamon, 1999; González & González, 2005; Vachon & Klassen, 2007). Overall, the number of firms that have been involved proactively towards maintaining the natural environment is still limited mainly to those that face certain pressures or requirements to consider environmentally-friendly aspects within the business environment (González & González, 2005). The increasing environmental awareness of different stakeholders has created a new competitive environment for firms which

now have to include their stakeholders' environmental concerns into their corporate agenda (Beamon, 1999; Vachon & Klassen, 2007).

Several authors argued that the degree of environmental initiative adoption depends on the internal and external pressures from various groups of stakeholders associated with the firms (Langerak, Peelen, & van der Veen, 1998; Menon & Menon, 1997). In addition, stakeholder theory points out that firms carry out activities to fulfil requirements and satisfy their primary stakeholders. As a stakeholder theorist, Clarkson (1995) distinguished primary stakeholders from secondary stakeholders. The participation and support of the former affect a firm's survival; customers, suppliers, and regulators fall into this category. Conversely, secondary stakeholders are not directly engaged in transactions with the firm, but affect and are affected by the firm at some point without affecting the firm's survival. Examples of this category of stakeholders are NGOs and the media.

Among these stakeholders, customers and regulators are the two most important stakeholders for firms in most industries, including the construction industry (Christmann, 2004; Etzion, 2007). Previous studies revealed that firms that perceive greater customer and regulatory pressures are more likely to be involved in environmental activities (Christmann, 2004; Lee, 2008; Wong & Fryxell, 2004). Furthermore, firms are facing constant pressures from the customers and regulators to innovate in ways that could reduce negative impacts on the natural environment (Kleindorfer et al., 2005; O'Brien, 1999; Sarkis et al., 2011).

In fact, nowadays, firms are required to respond quickly to pressures from regulators and customers through taking environmental changes into account. Several studies depicted that e-businesses have to provide fast response to outside pressures in order to keep up with changing demands, especially concerning environmental requirements. Notably, all types of organisations across industries are experiencing a similar situation. Thus, this study argues that regulatory and customer pressures might play an important role in driving the adoption of green innovation practices.

A number of researchers emphasised the influence of enforced regulation and legislation on firms' environmental practices (Delmas, 2002; Majumdar & Marcus, 2001; Rugman & Verbeke, 1998). Traditionally, regulatory forces have a significant influence by making firms comply with environmental regulations in order to decrease their environmental impacts (Banerjee, 2001; Walker, Di Sisto, & McBain, 2008).

Regulatory pressures which are oriented towards environmental improvements are usually exerted by governments. A number of environmental regulations or policies have been established to mitigate firms' impact on the environment, as well as create a context to drive firms to engage in environmental innovation. In the construction industry context, the introduction of environmental regulations is aligned with the promotion of green construction, which is aimed to control and reduce damage caused to the environment by construction activities (Wu, Chan, & Shen, 2004). Revell and Blackburn (2007) highlighted that the basic environmental consideration for builders in the UK is waste disposal. Therefore, duty of care⁵ and waste disposal regulations⁶ had driven most builders in the UK to dispose of their waste in an appropriate way.

Basically, regulators apply three approaches to encourage environmental reform within the construction industry, namely regulatory, fiscal, and voluntary. Duty of care and waste disposal regulations are the examples that fall under the regulatory category, whereas landfill tax⁷ and climate change levy⁸ are amongst those that fall into the fiscal category. Apart from that, numerous voluntary environmental programmes have been targeted, mostly at small and medium enterprises (SMEs) within the industry. Examples of these programmes are the Environmental Technology and Energy Efficiency Best Practice Programmes⁹ which focuses on raising awareness, as well as business support programmes including Envirowise. Furthermore, Revell and Blackburn (2007) found that the government has become more consultative towards

⁵ Duty of care regulations require construction firms to complete a waste transfer form, which ensure that waste is managed correctly and disposed safely.

⁶ Waste disposal regulations govern the storage, treatment, and disposal of hazardous waste.

⁷ Landfill tax is fees that are levied by waste collectors.

⁸ Climate change levy is tax on energy used by non-domestic users.

⁹ Other voluntary initiatives include Environmental Technology Best Practice, Groundwork Environmental Business Services Programme, Waste and Resources Action Programme (WRAP), ENWORKS, and Remade Network UK.

the construction industry as a whole in recent years. A lot of confederations and committees have been set up to hear the industry's view and provide consultation.

Nevertheless, legislation remains as the significant driver of the industry's environmental reform. For instance, waste disposal regulation has motivated the construction firms to organise their waste in an appropriate manner, while amendments to building regulations have driven more consideration on increasing the level of energy efficiency in the design of buildings (Revell & Blackburn, 2007). In particular, environmental regulations have covered many aspects including specifying technologies to be used, requiring specific environmental targets to be achieved, and offering economic measures by distributing environmental benefits and costs (Hartmann, 2006). These regulatory pressures force firms to follow the regulations in order to ensure their compliance (Patton & Worthington, 2003; Vickers, James, Smallbone, & Baldock, 2005).

On the other hand, customer pressure can be defined as the requirements or requests from firms' end consumers to reduce the negative impact on the environment (Ates, Bloemhof, van Raaij, & Wynstra, 2012). Generally, firms respond to customer requirements in most of their daily operations. The growth in environmental awareness amongst customers indirectly pushes firms to increase their environmental responsiveness by offering environmentally-friendly products or adopting greener technologies. The level of customer environmental awareness is expected to increase over time due to pressing environmental issues. Consequently, this pushes firms to increase their levels of environmental responsiveness further.

In addition, the number of environmentally-conscious customers keeps increasing (Hontou, Diakoulaki, & Papagiannakis, 2007). Therefore, firms that serve this customer group would be more motivated to implement environmental practices. This is supported by previous research which revealed that firms implementing environmental practices are motivated by customer forces. A survey by Henriques and Sadorsky (1996) found that after regulatory pressure, customer pressure was the second most cited source of pressure to implement an environmental management

plan. Besides, several studies stressed that customer pressure fosters more proactive environmental strategies (Delmas & Toffel, 2004; Gonzalez-Benito & Gonzalez-Benito, 2006; Henriques & Sadosky, 1999).

By looking from a different perspective, environmental pressures or requirements from regulators or customers offer a lot of positive aspects. According to Eiadat et al. (2008), environmental regulations offers a number of potential benefits for firms through facilitating them to overcome organisational inertia by leading them to accept new ideas, encourage creative thinking, highlight resource inefficiency, and outline possible investment in technological improvements. Similarly, environmental pressure from the customers encourages firms to increase their environmental awareness and lead them to gradually shift to environmentally-friendly mind-set by improving their environmental knowledge. Basically, these positive moves start with the optimisation of existing knowledge and the creation of new knowledge with the aim of reducing environmental impacts. In order to accomplish this, firm's absorptive capacity has to be developed (Lenox & King, 2004).

Even though an organisation encounters environmental pressures from the regulators or customers, environmental initiatives are hard to realise without the ability to acquire related potential knowledge or information that could facilitate their implementation. This ability is largely based on an organisation's absorptive capacity (Cohen & Levinthal, 1990) because all of the necessary skills for innovation are generally not available within a single firm (Inkpen & Beamish, 1997). This also applies to activities that require creativity including environmentally-friendly initiatives.

Notably, knowledge development which is closely related to an organisation's absorptive capacity is indirectly motivated by regulations and desire to fulfil customer requirements. As pointed out by Hilton, Archer and van Nierop (2000), knowledge development in SMEs is mostly driven by regulations through environmental training and education. In the same way, environmental requirements from customers encourage firms to improve themselves through involvement in environmental training and education, along with intensification of efforts to obtain useful information from various sources of knowledge. Pressures from regulators and

customers strongly benefit firms' ability to acquire, assimilate, and exploit knowledge because these pressures lead to the development of innovative solutions for environmental problems.

Therefore, this study posits that the construction firms that encounter higher levels of environmental pressures from regulators and customers are more encouraged to develop and enhance their absorptive capacity in order to facilitate the adoption of green innovation practices. Hence, the following hypotheses are proposed to consider the moderating effect of environmental requirements from the regulators.

H4a(i): Environmental pressure from the regulator positively moderates the relationship between a firm's existing knowledge utilisation and the adoption of green technical innovation.

H4a(ii): Environmental pressure from the regulator positively moderates the relationship between a firm's existing knowledge utilisation and the adoption of green process innovation.

H4a(iii): Environmental pressure from the regulator positively moderates the relationship between a firm's existing knowledge utilisation and the adoption of green administrative innovation.

H4b(i): Environmental pressure from the regulator positively moderates the relationship between a firm's knowledge building and the adoption of green technical innovation.

H4b(ii): Environmental pressure from the regulator positively moderates the relationship between a firm's knowledge building and the adoption of green process innovation.

H4b(iii): Environmental pressure from the regulator positively moderates the relationship between a firm's knowledge building and the adoption of green administrative innovation.

H4c(i): Environmental pressure from the regulator positively moderates the relationship between a firm's external knowledge acquisition and the adoption of green technical innovation.

H4c(ii): Environmental pressure from the regulator positively moderates the relationship between a firm's external knowledge acquisition and the adoption of green process innovation.

H4c(iii): Environmental pressure from the regulator positively moderates the relationship between a firm's external knowledge acquisition and the adoption of green administrative innovation.

Furthermore, another nine hypotheses are posited to consider the moderating effect of environmental requirements from customers.

H5a(i): Environmental pressure from customers positively moderates the relationship between a firm's existing knowledge utilisation and the adoption of green technical innovation.

H5a(ii): Environmental pressure from customers positively moderates the relationship between a firm's existing knowledge utilisation and the adoption of green process innovation.

H5a(iii): Environmental pressure from customers positively moderates the relationship between a firm's existing knowledge utilisation and the adoption of green administrative innovation.

H5b(i): Environmental pressure from customers positively moderates the relationship between a firm's knowledge building and the adoption of green technical innovation.

H5b(ii): Environmental pressure from customers positively moderates the relationship between a firm's knowledge building and the adoption of green process innovation.

H5b(iii): Environmental pressure from customers positively moderates the relationship between a firm's knowledge building and the adoption of green administrative innovation.

H5c(i): Environmental pressure from customers positively moderates the relationship between a firm's external knowledge acquisition and the adoption of green technical innovation.

H5c(ii): Environmental pressure from customers positively moderates the relationship between a firm's external knowledge acquisition and the adoption of green process innovation.

H5c(iii): Environmental pressure from customers positively moderates the relationship between a firm's external knowledge acquisition and the adoption of green administrative innovation.

In this model, absorptive capacity is supposed to contribute to green innovation adoption. Additionally, environmental requirements from the regulators and customers are perceived to play a moderating role on the relationship between absorptive capacity and green innovation adoption. In this logic, a greater degree of absorptive capacity is necessary if external pressure is high. A firm may foresee that regulatory and customer expectations will need to be integrated into the absorptive capacity development once pressure is exerted. In this case, absorptive capacity contributes to green innovation adoption, but the effect is greater when faced with external pressure. These relationships are illustrated in Figure 2.9.

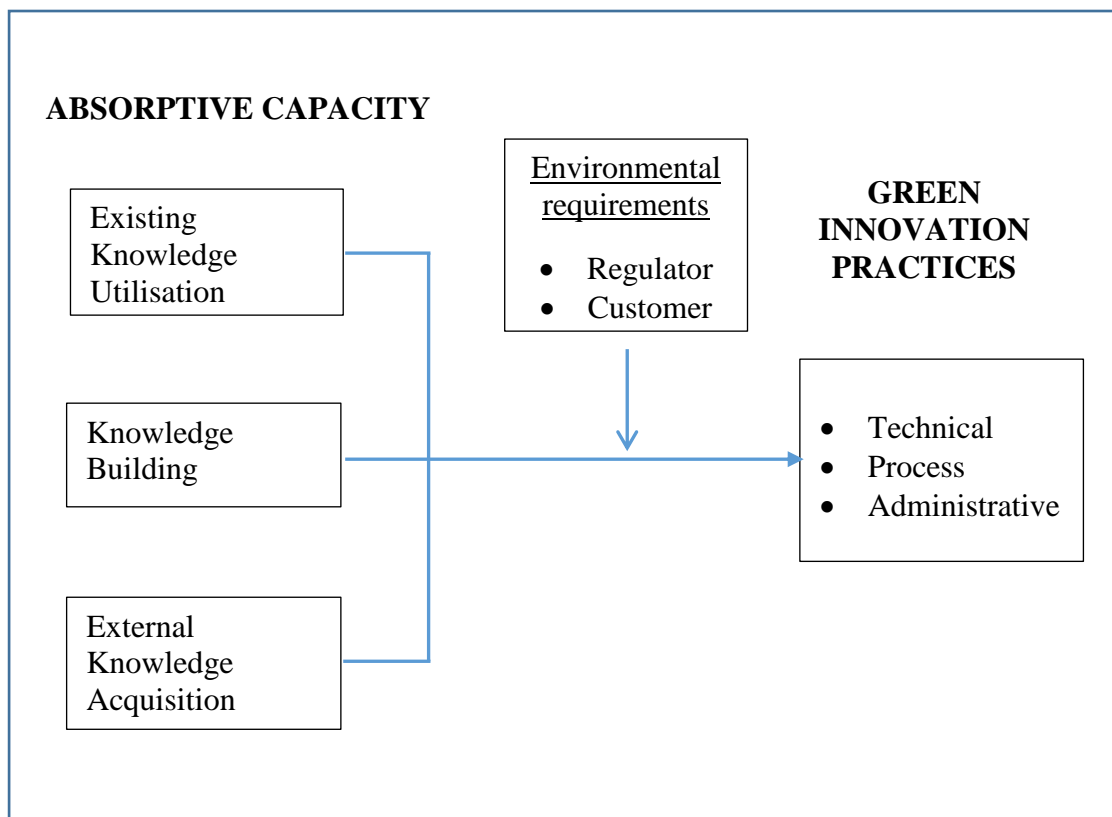


Figure 2.9: Research Framework

2.10 Concluding Remarks

This chapter offered a comprehensive review of the literature on green innovation adoption and its relationship with firms' absorptive capacity. The descriptions of the construction industry and the main participants in a construction project were also

provided in order to ensure comprehensive understanding of the industry's nature. In addition, this chapter also elaborated the moderating effect of regulatory and customer pressures on the relationship between a firm's absorptive capacity and green innovation adoption. Subsequently, this literature review was applied to assist the researcher in developing the hypotheses related to the research objectives.

The following chapter highlights the research methodology for this study. It discusses the research approach for data collection and the arising issues during the process.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

This chapter discusses the research methodology adopted for undertaking this study. It begins with an outline of the paradigm of inquiry concerning the study. Subsequently, justifications for selecting both quantitative and qualitative approaches are presented. This is followed by a discussion on the data collection methods which start from the process of instrument development until the validation of both instruments.

3.1 Investigating the Relationship between Absorptive Capacity and Green Innovation Adoption – The Research Paradigm

As highlighted in the conceptual model, this study attempts to investigate the relationship between absorptive capacity and green innovation adoption. The process requires the researcher to consider the overall research paradigm as it directly influences the selection of appropriate research approach and methods. Generally, there are two major paradigms in doing research, namely positivism paradigm (quantitative) and interpretivism paradigm (qualitative). According to Johnson and Clark (2006), these paradigms can be differentiated based on their underlying research philosophy (ontological or epistemological), methodology, and methods. In particular, the two paradigms reflect different research approaches undertaken by researchers towards the same phenomenon.

The positivism paradigm is based on the belief in an objective reality. In other words, knowledge can be obtained from data which are derived from the experience of independent observers (Goduka, 2012). Normally deemed as natural scientists, positivists tend to develop hypotheses from existing theory. These hypotheses will be tested and confirmed, in part or whole, for the theory's further development (Saunders, Lewis, & Thornhill, 2009). As elaborated by Creswell (2009), they are inclined to focus on explaining causal relationships by identifying causes which have certain influences on the outcomes in order to provide a basis for prediction and generalisation (Saunders et al., 2009; Scotland, 2012). Thus, positivists often generate data that are

collected through observation and direct experience by conducting surveys and experiments.

On the other hand, the interpretivism paradigm is concerned with the obligation to understand differences between people (Saunders et al., 2009) by understanding their world from their point of view (Goduka, 2012). Interpretivists tend to focus on understanding a phenomenon from a particular individual's viewpoint and investigating interaction among people (Creswell, 2009). Therefore, interpretivists are likely to conduct case studies, ethnography, and similar procedures which generate data from open-ended questionnaires, open-ended interviews and focus groups (Scotland, 2012).

In order to achieve the aim of this study – to examine the relationship between absorptive capacity and green innovation adoption empirically – the quantitative approach was adopted. This paradigm has a deductive nature which is demonstrated through its attempt to test a number of hypotheses based on an existing theory with the aim to generalise the sample results to the particular population. This approach was proven to contribute to better understanding of philosophy while exhibiting a high level of consistency through the application of methods that provide commonly accepted results (Ashby, 1964).

Although the deductive strategy is closely related to the application of quantitative methods and data, Blaikie (2010) contends that this is not mandatory. Hence, this study employed the qualitative method as well. Blaikie (2010) claims that the mixed method design is the most ideal approach to capture the best of both quantitative and qualitative methods. Furthermore, it is useful in facilitating the generalisation of findings to a population and the development of a detailed view on particular phenomena or concept. For this reason, the incorporation of qualitative approach elements within the positivism paradigm was considered appropriate. This is supported by Raftery, McGeorge and Walter (1997) who considered that some degree of methodological tolerance in combining paradigms is effective when it is appropriate. Greene and Caracelli (1997) added that different kinds of method are needed in order to comprehend the complexity of social phenomena better.

3.2. The Sequential Process of the Mixed Method Approach

Corresponding to the sequential explanatory design (Creswell, 2009), this research adopted the quantitative approach via a questionnaire survey to assess the association among the variables and confirm the research questions and hypotheses. The quantitative approach was selected as the most appropriate to be employed to answer the research questions for study being undertaken. This phase was then succeeded by the qualitative approach via interviews. The results of these interviews were used to assist in interpreting and explaining the findings of the quantitative results. This whole process is illustrated in Figure 3.1.

Specifically, in the first phase of data collection, a questionnaire survey was used to analyse the relationship between absorptive capacity and green innovation adoption as well as the moderating effect on the relationship. The results from the quantitative findings were then examined in more details in the second phase of data collection via a number of interviews. Finally, as both sets of findings were compared, the findings of qualitative results were used to explain in greater detail findings from the quantitative results.

As the positivism paradigm is the main approach of this study, higher priority is placed on the quantitative aspects. However, in the case of this study, the qualitative aspects of the work are also considered important as the findings could help to clarify trends and patterns identified in the findings of the survey. Notably, the use of mixed methods is the best approach in making comparison among organisations on the same basis and fulfilling the current research objective.

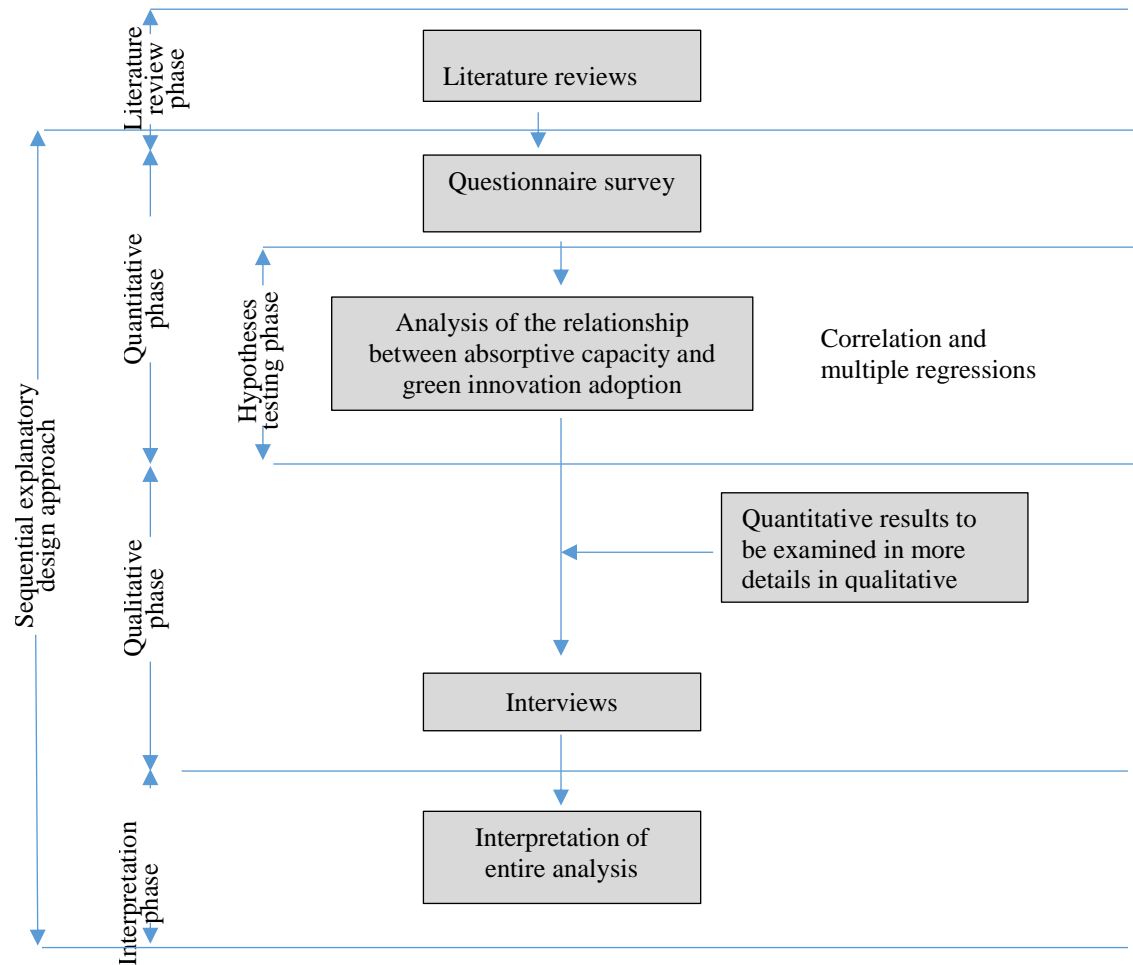


Figure 3.1: Process of Examining the Relationship between Absorptive Capacity and Green Innovation Adoption

Source: Developed by the author.

3.3 The Quantitative Phase

The quantitative approach was considered necessary for this study due to the fact that empirical research could provide evidence for explaining particular phenomena by addressing the questions of “how many”, “how much”, “how often”, or “to what extent” in the collection of numerical data (Aliaga & Gunderson, 2000). In the context of this study, the highly structured nature of this approach enables the researcher to establish the significant variables and their extent scientifically (Walker, 1997). Broad

conclusions can be made from the sample and this allows their generalisation to a population (Polit & Beck, 2010).

There are three main approaches that are typically employed in conducting quantitative research. Blaikie (2010) identified them as questionnaire survey, structured interview and structured observation. This study employed one of the most commonly used quantitative data collection methods in the social sciences: the questionnaire survey (Blaikie, 2010).

3.3.1 Survey

Considered as one of the leading means in the social sciences (Blaikie, 2010), a survey builds on previous work that has established theories and principles which could facilitate in selecting the appropriate data required by a particular research project (Fellows & Liu, 1997). The survey can be categorised into cross-sectional or longitudinal studies through administering questionnaires or conducting structured interviews for the purpose of generalising the results from a sample to a population (Creswell, 2009). This approach has limitations such as the risk of response bias and low response rate, especially for the questionnaire survey. Nevertheless, it offers the opportunity to discover a broad range of issues from a large sample of individuals.

In this study, a survey was adopted to obtain a quantitative description of the population by studying a sample of that population. Particularly, a cross-sectional questionnaire survey was constructed of building firms within the construction industry in Scotland. In general, there are many types of questionnaire with unique merits and demerits, namely self-administered, postal, and online survey (Blaikie, 2010). After carefully evaluating the advantages of each option, the researcher decided to choose an online survey due to its inherent advantages over the others.

The main advantage of the online survey is its relatively cheaper cost compared to postal and self-administered surveys (Bryman, 2006). Moreover, Yun and Trumbo (2000) emphasised that the online survey is ideal when faced with limited resources. Thus, online survey was chosen for this research due to the constraint of resources as

the target population is limited, the respondents' preference to be contacted electronically, and the respondents' geographical spread. This method also saved the researcher's time, money, and effort that otherwise might have been spent on travel or postage charges. Apart from that, the adoption of this method minimised risks such as undeliverable mail and the risk of respondents having changed address (Blaikie, 2010).

Specifically, the questionnaire was created using an online survey platform called Bristol Online Survey (BOS). It offers a user-friendly interface and advanced survey tool which simplifies the process of creating the questionnaire. In addition, it is a secure website which requires a password for controlling access and stores the completed surveys safely. These features greatly benefitted the researcher in creating and maintaining the survey.

The online survey was targeted at firms/organisations in the Scottish construction industry. The targeted respondents were someone who had knowledge regarding environmental and innovation strategy matters of the firm, such as the environmental/R&D manager, or other senior manager or individual holding an upper management position as they were more familiar with the company's operation as a whole. Notably, the unit of observation was focused on the firm's level of involvement in green activities and practices, as well as the firm's absorptive capacity in terms of utilisation of existing knowledge, knowledge building effort and external knowledge acquisition.

3.3.2 Identification of Sample Firms

The population of this study was general construction/building firms¹⁰ in Scotland. A general building firm is considered as a firm which deals with the major processes of assembly and procurement of land for construction purposes (McCoy et al., 2009). As this study intended to examine the level of green innovation adoption related to the technical, process, and administrative aspects of a firm, general builders were the most

¹⁰ Throughout the thesis writing, the terms 'construction firms' and 'building firms' are used interchangeably.

ideal population. They are involved in a major part of or the entire process of construction work and hence, they would be able to provide related information on more specific areas of activity compared to companies that only specialised in certain aspects of construction work.

In order to identify the sample firms, the directory of Federation of Master Builders (FMB) was used as the sampling frame. The FMB is UK's largest trade association in the building industry which was established to protect the interests of SME building firms (FMB, 2014). Its members mostly consist of general builders who were the target respondents for this research.

A database was then generated to develop a long list of the sample firms. Out of nearly 11,000¹¹ companies throughout the UK which were listed on the FMB website in alphabetical order, a total of 433 builders in Scotland were extracted for the research database. However, the 433 FMB members in Scotland comprised not only general builders, but also carpenters, joiners, as well as specialists in roofing, kitchen building/installation, brickwork and plastering, therefore, a second round of extraction was done to identify the general builders. Apart from that, the FMB directory only provided the name, address and type of specialisation of members, without any contact telephone number or e-mail address. Since this study was using an online survey or administration of questionnaire through e-mail to collect data, the e-mail addresses of the companies were vital.

Telephone numbers, at least, would allow the researcher to contact the firm and ask for a suitable contact e-mail address. Several approaches were made to the FMB in an attempt to obtain such contact details but were unsuccessful as the organisation does not allow anyone to access its members directly from the FMB office. Moreover, their members had declared previously their wish to not be approached by individuals or companies via the FMB. In order to cope with this situation, a comprehensive search was undertaken to obtain the builders' e-mail address or contact number from the

¹¹ Number of construction companies in the UK which were offering various ranges of construction works/services, including general building works provided by builders.

Internet. This time-consuming effort resulted in the identification of the contact information needed for most of the companies. However, the researcher did not manage to find the contact details of firms which did not have their own website. These particular companies were normally very small firms, often one person businesses, which worked independently within their local community. Since they could not be contacted, these companies were excluded from this sample. After the final extraction, a total of 392 companies remained in the database.

In addition, an extensive search for general builders in Scotland via the Internet was conducted. A large number of websites owned by the construction companies in Scotland were analysed to identify any general builders. This was another time-consuming effort that was performed to generate details of additional respondents to take part in the survey. As a result, 83 additional general builders in Scotland were identified to be invited to participate in the study.

Apart from that, the researcher visited a number of builders to invite them to be a part of the study. A list of general builders who operated in the surrounding area of Edinburgh was identified through thomsonlocal.com's annual local business directory for the year 2014-2015. These builders were chosen due to their close geographical proximity which minimised the time and cost constraints experienced by the researcher. Since most of the construction companies listed and advertised in the directory were specialists in certain construction areas, only a small number of general builders were identified. In particular, 28 of these general builders identified were randomly selected to be visited. The sample sources discussed above are presented in Table 3.1.

Table 3.1: Sample Sources

Sources	Sample size (<i>n</i>)
FMB directory	392
Websites	83
Thomson Directory for Visits	28
Total	503

3.3.3 Questionnaire Development

The items in the questionnaire were developed based on the literature review. Since it is well known that to succeed in collecting data, proper questionnaire design is vital (Creswell, 2009), the structure and appearance of the questionnaire were designed to be “respondent-friendly” in order to assist the respondents in understanding and answering all of the questions easily, as well as to maximise the response rate. As the questionnaire was considered as the main data collection tool, considerable effort was undertaken towards this endeavour.

The questionnaire development process involved a number of methodological steps as illustrated in Figure 3.2. Notably, the green innovation and absorptive capacity constructs, as well as the individual items, were derived from the literature review. In order to assess face validity and content validity, two academics from the University of Edinburgh and Napier University of Edinburgh, respectively, as well as two practitioners who worked in two different construction companies, were contacted through e-mail to get their feedback on the developed items. As a result, several items were revised to improve their precision and specificity. The online survey was designed and developed before being administered to the dedicated respondents for pilot testing.

The final questionnaire comprised six sections. The first section sought to gather general information about the respondents, while the second section explored the basic information about their company, such as the name of company, number of employees, ownership, main business activity and year of establishment. Sections three to five contained questions on the five dimensions of absorptive capacity, namely (i) prior relevant knowledge, (ii) communication climate, (iii) education and training, (iv) environmental scanning, and (v) external linkages. Lastly, the final section covered the measurement of green innovation practices, together with the measurement of environmental requirements from the regulators and clients. The following discussion outlines the definition and measurement of the constructs.

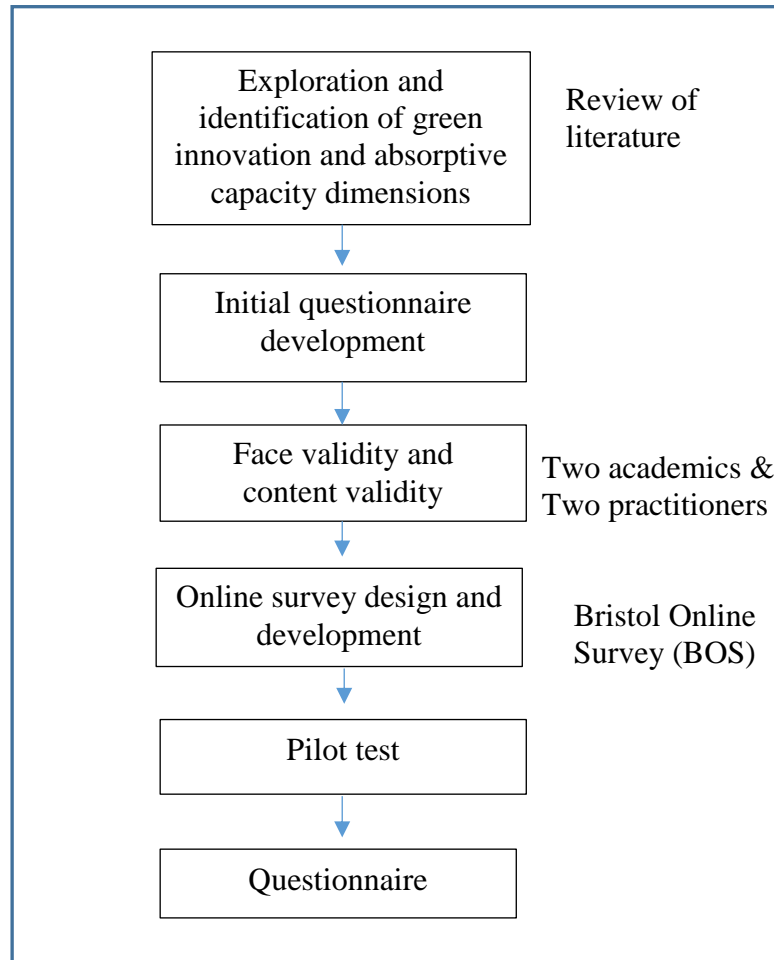


Figure 3.2: Questionnaire Development Process
Source: Developed by the author.

3.3.3.1 Independent Variables - Absorptive Capacity

Absorptive capacity is a complex construct which is difficult to operationalise (Zahra & George, 2002). As previously described in the literature review, an organisation's absorptive capacity is a multi-dimensional construct. This study measured absorptive capacity by looking at five dimensions: (i) prior relevant knowledge; (ii) communications climate; (iii) education and training; (iv) environmental scanning, and (v) external linkages.

The first dimension of absorptive capacity, which is prior relevant knowledge (PRK), is the easiest to measure compared to others. It can be operationalised to a large cross

sectional study as it is based on a firm's stock of prior knowledge. Prior relevant knowledge is determined by the firm's existing knowledge that reflects the education, competencies or individual skills of its employees. Specifically, the measurement of the stock of knowledge of employees will look at the employees' level of general and technical knowledge, general education and job competencies (Gavronski, Klassen, Vachon, & do Nascimento, 2012). In order to measure this construct, the respondents were asked to answer four questions by indicating their agreement on the level of particular knowledge of employees from 'strongly disagree' (1) to 'strongly agree' (5).

The measurement of the second dimension of absorptive capacity called communication climate (CC) consists of four items with an instrument based on Terziovski (2010), which was used in the manufacturing sector. The respondents were asked to rate their agreement related to questions on the organisational culture that shapes their direction towards adoption of green innovation from 1 (strongly disagree) to 5 (strongly agree) based on the following statements: (i) Our employees share ideas freely with each other; (ii) Our employees share an open communications environment; (iii) Our employees have no difficulty accepting new ideas, and (iv) Our employees are willing to accept changes.

Further, this study referred to Daily, Bishop and Massoud (2012), Nieto and Quevedo (2005) as well as Curkovic, Melnyk, Handfield and Calantone (2000) to measure the third dimension of absorptive capacity that is education and training (ET). It represents the firm's training effort to gain related knowledge in facilitating them to engage in green innovation practices. The respondents were asked to state their agreement on the involvement of employees in training that directly aimed at the development and/or introduction of green innovations. A five-point Likert scale was used to rate each particular item with 1 being 'strongly disagree' and 5 being 'strongly agree'. The items were (i) an adequate amount of training in environmental issues is provided for employees within our company; (ii) employees receive environmental training frequently; (iii) employees use their environmental training effectively; (iv) employees have many opportunities to get environmental training, and (v) our firm invests a great deal in environmental training.

The fourth dimension of absorptive capacity that is environmental scanning is measured by looking at the firm's efforts to obtain knowledge from external sources. As claimed by Caloghirou et al. (2004), existing knowledge cannot solely be relied on to perform innovation effectively, thus, the effort to obtain knowledge from external sources seems necessary to strengthen the firm's existing knowledge. This effort can be viewed through two elements namely the firm's openness to external sources of knowledge and establishing external linkages. In this study, environmental scanning was measured by looking at the importance of professional and scientific information as a source for environmental-related information to acquire related knowledge. In detail, six items have been adapted from Bigliardi and Dormio (2009), Mol and Birkinshaw (2009) as well as Kang and Kang (2009) to measure the importance of following information sources: (i) conferences and fairs; (ii) literature and scientific papers; (iii) professional associations; (iv) professional periodicals; (v) media, and (vi) information networks. For that purpose, the respondents were asked to indicate the level of agreement for the importance of each information source based on a five-point scale anchored by 'strongly disagree' (1) and 'strongly agree' (5).

Regarding the fifth dimension of absorptive capacity, external linkages refers to collaboration with other actors within the industry or with different industry. Previous research has shown that the mere availability to access external knowledge might be inadequate to encourage a firm to become involved in innovative activities. Instead, collaboration with other actors might be important. There are a number of literatures claiming that external linkages are important sources in gaining knowledge and building capabilities (Ahuja, 2000; Sparrowe et al., 2001). The linkages with particular actors were measured using an instrument adapted from Brettel and Cleven (2011). The respondents were asked to indicate on a Likert scale from 1 (strongly disagree) to 5 (strongly agree) their agreement with the statement related to knowledge acquisition from suppliers, customers, competitors, regulators, environmental organisations, universities and industry associations that assists them to become engaged in green innovation. The measurement of the construct for the absorptive capacity factors is shown in Table 3.2.

Table 3.2: List of Questionnaire Items and the Measurement Scale for the Independent Variables

Factors	Items
Independent variables	
Prior relevant knowledge (PRK)	(PRK1) Our employees' overall technical knowledge is high (PRK2) Our employees' general education level is high (PRK3) Our employees' overall job competence is high (PRK4) Our employees' general knowledge level is high
Communication climate (CC)	(CC1) Our employees share ideas freely with each other (CC2) Our employees share an open communications environment (CC3) Our employees have no difficulty accepting new ideas (CC4) Our employees are willing to accept changes
Education and training (ET)	(ET1) An adequate amount of training in environmental issues is provided for employees within our company (ET2) The employees receive environmental training frequently (ET3) The employees use their environmental training effectively (ET4) The employees have many opportunities to undertake environmental training (ET5) Our firm invests a great deal in environmental training
Environmental scanning (ES)	Agreement on the importance of the following sources of environmental-related information: (ES1) Conferences and fairs (ES2) Literature and scientific papers (ES3) Professional associations (ES4) Professional periodicals (ES5) Media (ES6) Information network
External linkages (EL)	Agreement on the importance of the following sources of environmental-related information: (EL1) Suppliers (EL2) Customers (EL3) Competitors (EL4) Regulators (EL5) Environmental organisations (EL6) Universities (EL7) Industry associations

A five-point scale: 1 = *Strongly disagree*, 2 = *Disagree*, 3 = *Neutral*, 4 = *Agree*, 5 = *Strongly agree*

3.3.3.2 Dependent Variables - Green innovation adoption

This study divided green innovation into three categories namely green technical innovation, green process innovation and green administrative innovation. Green technical innovation was measured with an instrument based on Huang et al. (2009)

as well as adapted from Qi et al. (2010). The respondents were asked to specify on a Likert scale from 1 (strongly disagree) to 5 (strongly agree) their agreement with a series of statements related to the adoption of following technologies: (i) technologies of energy conservation; (ii) technologies/ processes of pollution prevention, and (iii) technologies of noise controlling.

On the other hand, green process innovation was measured using an instrument adapted from Sev (2009) and Chen et al. (2006). Based on a five-point Likert scale, the respondents were asked to state the degree of their agreement with the statements that reflect their consideration on the environment during the implementation of construction activities anchored by 'strongly disagree' (1) and 'strongly agree' (5) for the following items: (i) Emission of hazardous substances or waste during construction activities are monitored; (ii) Our company utilises, integrate with or recommends adoption of site waste management plan; (iii) Energy is used efficiently during construction; (iv) Materials that require low energy to produce where possible are specified or used during construction; (v) Locally sourced materials is used for construction activities to reduce energy use for transport, and (vi) Natural environment is conserved during construction activities.

Further, this study referred to the instruments developed by Huang et al. (2009), Sev (2009), Jaskyte (2004), Lefebvre, Lefebvre and Talbot (2003) and Smallwood (2000) which have been adapted to measure the green administrative innovation adopted by the construction companies. A five-point Likert scale was used to assess the degree of agreement with the statements pertaining to the implementation of administrative process, new management systems and employee development programmes within the firm which is rated from 'strongly disagree', 'disagree', 'neutral', 'agree' to 'strongly agree'. The items include the adoption of: environmental auditing; environmental protective education and training; environmental-based incentive/rewards systems; new activity or event for staff training to environmental-related issues, and written environmental documentation. The list of questions and the measurement scale for the green innovation factors are shown in Table 3.3.

Table 3.3: List of questionnaire items and the measurement scale for the dependent variables

Factors	Items
Dependent variables	
Green technical innovation (GT)	(GT1) Our company adopts the technologies of energy conservation
	(GT2) Our company adopts the technologies/ processes of pollution prevention
	(GT3) Our company adopts the technologies of noise controlling
Green process innovation (GP)	(GP1) Emission of hazardous substances or waste during construction activities are monitored
	(GP2) Our company utilises, integrates with or recommends adoption of site waste management plans
	(GP3) Energy is used efficiently during construction
	(GP4) Materials that require low energy to produce where possible are specified or used during construction
	(GP5) Locally sourced materials are used for construction activities to reduce energy use for transport
	(GP6) Natural environment is conserved during construction activities
Green administrative innovation (GA)	(GA1) Our company adopts environmental auditing
	(GA2) Our company undertakes environmental protective education and training
	(GA3) Our company offers employee remuneration and promotion based on environmental initiatives/ improvements
	(GA4) Our company promotes new activities or events for staff linked to environmental-related issues
	(GA5) Our company provides written environmental documentation such as policies, a mission statement, rules or procedures to protect the environment

A five-point scale: 1 = *Strongly disagree*, 2 = *Disagree*, 3 = *Neutral*, 4 = *Agree*, 5 = *Strongly agree*

3.3.3.3 Moderating Variables - Environmental Requirements

As environmental requirements from regulators and customers are perceived as playing a moderating role on the absorptive capacity and green innovation adoption

relationship, four respective items were used to measure both moderators. Again, a five-point Likert scale was used to evaluate the degree of respondents' agreement with the statements related to environmental pressure they are facing from the regulator and their customers, which have been adapted from Paulraj (2009), Fraj-Andrés, Martínez-Salinas and Matute-Vallejo (2009), Gadenne, Kennedy and McKeiver (2008) and Ates et al. (2012). The measurement of the construct for the moderating variables is shown in Table 3.4.

Table 3.4: List of Questionnaire Items and the Measurement Scale for the Moderating Variables

Moderating variables	
Regulatory pressure (RP)	(RP1) Environmental regulation is the primary driver for all our environmental activities
	(RP2) Our environmental activities are directed towards complying with regulations
	(RP3) Regulation by government agencies has greatly influenced our firm's environmental strategy
	(RP4) Environmental legislation is not relevant to our business
Customer pressure (CP)	(CP1) Customer pressure is the primary driver for all our environmental activities
	(CP2) Our customers expect our firm to be environmentally friendly
	(CP3) We engage in environmental friendly activities because of customers' environmental consideration when making choices
	(CP4) Customers require detailed information to be assured of our environmental compliance
A five-point scale: 1 = <i>Strongly disagree</i> , 2 = <i>Disagree</i> , 3 = <i>Neutral</i> , 4 = <i>Agree</i> , 5 = <i>Strongly agree</i>	

All these questions were systematically presented in the online survey platform hosted by Bristol Online Survey (BOS).

3.3.3.4 Control Variables

A control variable is a variable that is not the focus or planned as part of a research study (Gonzalez-Benito & Gonzalez-Benito, 2006). However, its existence cannot be ignored as it may have a certain impact on the dependent variable(s). Even though a control variable is usually not included as part of a hypothesis statement, it is included in the research model testing, together with other independent variables. It is called a control variable as it kept under ‘control’ or ‘constant’ to observe its impact in the relationship between the independent and dependent variables (González-Benito & González-Benito, 2006).

Firm size has traditionally been considered as an important control variable. The larger the firm, the more it is likely to have more resources to adopt innovations (Kitchell, 1995) and become proactive in natural environmental management (Aragón-Correa, 1998). In contrast, small firms need to face the complexity and high investments in switching to greener technologies and practices (Hemmelskamp, 1999). Therefore, this study controlled for firm size which was measured by the number of full-time employees in the firm.

3.3.4 Pilot Survey

Prior to implementing the main survey, a pilot test was performed by administering the questionnaire to a small group of respondents that were similar to the target population. The main reason for carrying out the pilot test is to evaluate the clarity and relevance of the questionnaire as a whole. Such a test run of the survey is considered necessary to demonstrate the methodological rigour of a particular survey (Dulaimi, Ling, Ofori, & De Silva, 2002). Also, it is important to identify any ambiguities or questions that can be considered as difficult to answer as well as identifying any unnecessary questions. Therefore, a sample of 33 construction companies that were identified randomly from the internet was emailed to invite their participation in the survey. Along with the link to the online survey, the purpose of the survey was explained to each respondent.

By allocating a period of one month to conduct the pilot study, which was in January 2014, ten percent of the sample had submitted their completed survey. During the period, two reminders were emailed to each company, with the first reminder issued one week after emailing the survey invitation. The second reminder was emailed one week later in order to improve the response rate. However, the response rate remained the same even after a number of contacts and conversations with the non-responding companies through telephone calls, as they have voiced their lack of time to participate in the survey.

Bearing in mind the limitation in terms of time, the feedback received from the participating respondents could be considered as adequate since all the responses had raised the same issues to be concerned with. The feedback revealed a few problematical questions related to dimensions of the communication climate which had to be rephrased as the questions were not answered as anticipated. Besides, a few questions on the dimension of external linkages were also re-worded as the feedback from the respondents appeared to show ambiguity. These amendments were also done based on a number of discussion sessions with two academics at the University of Edinburgh. Yet, the aim of conducting the pilot study had been achieved where it had provided an opportunity to test the adequacy of the research instrument which resulted in improvement to the questionnaire.

3.3.5 The Main Survey

Three approaches were taken to administer the online survey. First, the survey invitation was emailed to FMB members in Scotland which had been extracted from a large number of construction companies in Scotland to leave only members that were considered as general building firms (See invitation letter in Appendix 1). The second and third approaches were undertaken based on the back-up plan in the case of a low response rate being received. For the second approach, additional invitation emails were sent to a number of building firms in Scotland that had been identified from searching the internet. Finally, a few visits were undertaken to a number of construction companies in the surrounding area of the City of Edinburgh. All three

approaches required participants to complete the online survey, which took around 20 minutes (see the questionnaire in Appendix 2).

The first approach involved 392 construction companies or builders with valid email addresses who were invited to participate in the survey. The survey was launched on March 10th 2014 for a period of four months. The invitation email was addressed to someone within the company that can be considered as knowledgeable in most of their company's activities such as the Managing Director, General Manager and Proprietor or someone who was working closely with the company's environmental matters, such as Environmental Manager or Research and Development (R&D) Manager. The recipients were sent an email with a link that would lead them to the survey page.

The first approach, however, received a frustratingly low rate of responses, even after a reminder had been emailed to the non-respondents. In order to increase the response rate, additional effort was put in by searching for Facebook accounts of each building firm with the purpose of making it easier to make contact or engage in a conversation with them. This effort seemed necessary as conversations with the respondents are possible whether in real time or through private messages, thus, any queries could be raised quickly by the respondents. However, only a small number of building firms have Facebook accounts that can be considered as an active member in the social networking platform. Consequently, the survey invitation and the link to the survey was sent once again through private messages to the particular identified builders. The invitation to take part in the survey through the builders' Facebook account resulted in slightly increasing the response rate. As a number of conversations were created through private messages, most of the respondents replied to state their support and willingness to take part in the survey.

The second approach involved administering the survey to general builders in Scotland that were identified through extensive searching from the internet. A total of 83 general builders with valid contacts were identified and they were invited to participate in the survey. The two approaches were conducted using the same procedure with invitation emails sent to each company in the first place, followed by a series of reminders. One

week after emailing the survey invitation, the first reminder was issued to the non-respondents. The second and third reminders were then issued, respectively, one week after sending the previous reminder in order to encourage more companies to respond.

As the response rate from the first two approaches still did not reach a satisfactory level for analysis, the final approach that was taken to get more responses was by visiting a number of builders that operated in the surrounding area of Edinburgh city. A total of 28 builders were visited by knocking on their doors in several separate visits according to different areas as shown in the Table 3.5. These visits were conducted within one month; that was in the final month of the data collection period for the survey.

Table 3.5: Areas around Edinburgh that were Visited for the Survey

Area	Number of companies
Leith	4
Marchmont & Morningside	4
Stockbridge & Granton	4
Craigmillar	2
Sighthill	3
Straiton	2
Dalkeith	5
Musselburgh	4
Total	28

In conclusion, out of 458 invitations sent out to the potential respondents, 84 usable responses were received from the three groups of respondents; FMB general builders in Scotland, respondents identified from Internet search, and respondents who were visited personally, indicating an 18.3 % response rate.

3.3.6 Quantitative Data Analysis

The completed surveys received from the three approaches were securely stored in Bristol Online Survey (BOS) website, and they were later retrieved by the researcher

for analysis. The raw data of the survey were then transferred into a statistical software package. All the data was analysed using Statistical Package of Social Sciences (SPSS) version 21. SPSS is one of the most widely available and powerful statistical software packages that covers a broad range of statistical procedures. Even although it has limitations when it comes to advanced modelling and development of statistical approaches (Blaikie, 2010), SPSS was considered sufficient to perform all the analysis needed to answer the research questions as they did not require the use of sophisticated statistical techniques. The comprehensive analysis of the survey will be discussed in detail in Chapter 4.

3.3.7 Validity and Reliability

A good questionnaire is supposed to be valid and reliable. While validity is concerned with the extent to which an instrument measures what it is supposed to measure, reliability is concerned with the ability of an instrument to measure consistently, which indicates how free it is from random error (Pallant, 2013). Thus, before further quantitative analysis based on the survey was conducted, the reliability and validity of the items for the factors under the three sections of the survey questionnaire that consist of the dependent variables, independent variables, and moderators were tested.

The process for conducting Principal Component Analysis (PCA) is well-documented in multivariate statistics literature (Manly, 1994; Subhash Sharma, 1996). Generally, there are seven steps in a PCA: (i) construct a data matrix, (ii) standardise variables, (iii) calculate the covariance matrix, (iv) find eigenvalues, (v) select factors, (vi) interpret the results, and (vii) calculate scores. For each set of variables in this study, one PCA was implemented. Thus, three PCAs were constructed, one for dependent variables, one for independent variables, and one for the moderators. PCA was used to determine the validity of the underlying dimensions of the dependent variables, independent variables, and moderators.

Once all the dimensions were determined through conducting PCA, Cronbach's Alpha was used to examine the reliability of the instrument. Specifically, it measures internal consistency reliability by examining how well the items on test measure the same construct or idea (Pallant, 2013). While validity is necessary, it alone is not sufficient. For a test to be valid, it also need to be reliable. Based on the results of both tests, the instrument for this study, therefore, has achieved the satisfactory level of validity and reliability. Results of both tests are reported in Chapter 4.

3.4 The Qualitative Phase

In order to get further views in detail following the quantitative study undertaken earlier, a qualitative approach should be given considerable attention as it could provide better understanding on differences between people (Saunders et al., 2009) by understanding their world from their perspective (Goduka, 2012). The ways people think and communicate are considered important for researchers who undertake this approach as it could offer value in terms of richer information to be added to existing information. The principal aim of this approach is trying to answer 'how?' and 'why?' questions (Walker, 1997) or trying to develop themes from collected data (Creswell, 2009).

Qualitative study normally includes case study, phenomenology, hermeneutics or ethnography where the data are usually collected through open-ended questionnaires, open-ended interviews and focus groups (Scotland, 2012). This study employed interviews as it was considered as an appropriate method for collecting data required for this phase to enable the deeper explanation of related information to be obtained.

3.4.1 Interviews

It has been claimed that interviews are the most commonly used qualitative method in organisational research (King, 1994). Besides, since the study intention was to understand the participants' perceptions, experience and opinions regarding their involvement in green practices, an interview was considered as the most appropriate

method in terms of economical side and ease of reaching participants. Other alternative methods within a qualitative methodology, such as participant observation, focus groups and document analysis could equally generate fruitful ideas but their use was constrained by resources in terms of cost, time and the challenge of bringing all the necessary persons to one place as in a focus group. Hence, for practical reasons in relation to cost and feasibility, as well as the scope of the study, the interview was settled on as the most appropriate data collecting instrument for the second phase of the research.

There is a range of interviewing techniques, including structured interviews, semi-structured interviews and unstructured interviews (Flick, 2006). Semi-structured interviews were chosen over the other options given that questions from the prior quantitative study could be utilised to develop further questions for the interviews. Besides, it was possible to explore areas of interest which might arise during the interview which were not limited to prior quantitative questions. Therefore, it seemed that it was the best way to discover what was important to the participants while trying to avoid biasing their responses.

Specifically, face-to-face interviews were employed to capture the depth of information required for this phase. Moreover, in certain cases, it was necessary to see the reactions of the respondents so that it would be easier to understand what is really important to them. By sitting in the same room with the interviewee, the likelihood is that more information would be gathered naturally in a live environment.

For this phase, a number of interviews were conducted from November 2014 to March 2015. This involved issuing an invitation for research participation to potential participants, arrangement of appointments with research participants as well as interview sessions on particular dates and in different locations.

3.4.2 Sample Selection Criteria

The selection of sampling method can be classified as probability and non-probability (Hair, Money, Samouel, & Page, 2007). In probability sampling, members of a population are selected randomly which allow each member to have an equal chance to be selected. This type of sampling method is widely used in quantitative studies and normally deals with large sample size. With non-probability sampling, not every member of the population has a chance of being selected, leaving it to the researcher to make the selection based on his or her judgement. This type of sampling method normally aims for a smaller sample and specifies certain criteria to choose the appropriate participants for a specific purpose. However, non-probability sampling can often be viewed as an inferior alternative to probability sampling method which also has its own weaknesses (Hair et al., 2007). One of the major weaknesses is the potential of sampling bias made by the researcher which can mean that the sample may or may not represent the population well. In addition, it is difficult to draw inferences to the target population (Scotland, 2012).

Regardless of the limitations, this study used one of the non-probability sampling methods, that is, purposive sampling. Purposive sampling can be useful to ensure relevant samples are selected in order to enrich the study. Normally, certain criteria are specified initially to select relevant participants who would be able to add value to the research, otherwise it would not provide any relevant information. In the context of this study, the selection of appropriate participants would be helpful to explain in more detail certain issues that arose from the quantitative study that had been undertaken previously. Figure 3.3 illustrates the criteria in selecting the interview sample. The participants can be divided into two groups; representatives of the building firms and the other industry members. For the first group, approximately 32 potential respondents who were builders had been approached and six finally agreed to participate in the interview, while the others could not give any commitment to participate in the interview due to an abundance of work. The second group of participants consisted of seven industry experts who dealt directly or indirectly with environmental matters and issues in the construction industry.

Based on the findings from the survey, the level of adoption of green practices is different from one company to the other especially between small and large companies, and new and established companies. However, accreditation status held by certain companies influenced the adoption of green practices as well. These three factors could offer rich information from three different perspectives on issues related to green practices adoption. Therefore, by looking at the high and low level of each category, the findings between them could be compared.

However, it was very challenging indeed to get firms to agree to participate in the interview. Some of the potential participants refused to be interviewed immediately while some of them could not manage to allocate even some time to be interviewed due to a shortage of time due to work commitments. The researcher had tried very hard to contact the potential participants a number of times and to convince them to participate in the interview as their contribution was valuable for the study, but eventually only six agreed to be interviewed. Fortunately, the six building firms which agreed to be part of the study were representative of each category that the researcher was looking to get information from (large and small companies, new and established companies, and ISO 14001 accredited and non-accredited companies) allowing the researcher to proceed without the need to approach further companies to fulfil the categories. Thus, the possibility of obtaining data representing different types of companies was greater and the credibility of the data was improved somewhat. Furthermore, the number of participants, six, was considered as being sufficient to provide some depth and breadth of views. There were many discussions in the literature of the appropriate number of participants for similar study of this, which ranged from two to fifteen (Creswell, 2009; Silverman, 2006; Yin, 2003). Hence, the researcher was satisfied with six since it covered different types of companies to represent the industry.

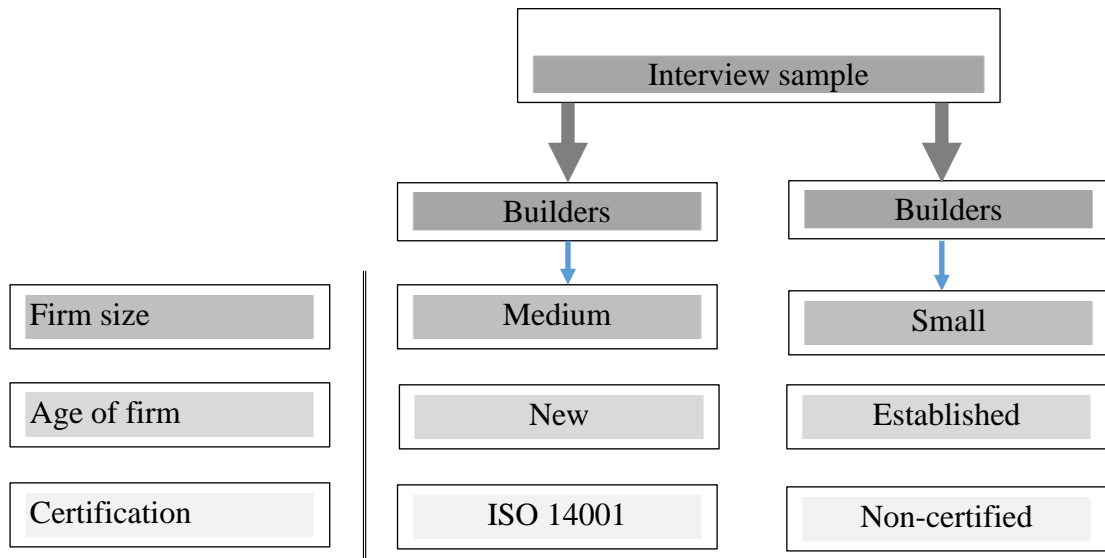


Figure 3.3: Typology of Sample Selection for Interview among the Group of Building Firms

In addition, seven additional participants were also interviewed to represent the industry experts which were considered as having a close relationship with the building firms. An architect, a representative of one of the trade associations in the building industry (the Federation of Master Builders), a representative of Edinburgh Centre for Carbon Innovation (ECCI), a representative of Zero Waste Scotland, a representative of Construction Scotland Innovation Centre (CSIC), a representative of Building Standard Division in Scotland, and an environmental engineer from RSP Consulting LLC, were selected to provide information as well as answer questions related to some unexpected results that arose from the earlier quantitative study. The interviews that involved these industry experts provide additional views from other perspectives. They offered the kind of answers which expanded on the ‘why’ aspect of answers that had been provided by the building firms themselves. Thus, other aspects of an issue could be revealed from their different perspective which could offer deeper understanding regarding it.

3.4.3 Development of Semi-structured Interview Questions

As this was the second phase of data collection, the questions from the earlier quantitative study were used as guidance in developing more open questions for the interviews. To develop a list of appropriate questions for the semi-structured interview, a chart with all the variables and critical findings from the quantitative study was created to harvest the identified data points. In addition, as the main reference was the questionnaire itself, these questions were then broadened in order to capture specific, unknown or unexpected information from the participants.

Two set of interview questions were developed for the different group of participants: representatives of the building firms and the industry experts. The interview questions for the representatives of the building firms were based on the survey questionnaire which had been broadened with several follow-up questions for most of the questions to get into details of aspects under study. The questions were designed in three sections (see Appendix 3). The first section of the questions focused on the background of the participants and their company. This was to provide both participant and interviewer with a chance to get acquainted. The next section of the interview focused on the role of absorptive capacity in terms of existing and new knowledge related to environmental issues and practices, while the final section concentrated more on investigating the level of the participants' company involvement in any environmentally-friendly activities and practices.

The interview questions for the industry experts were slightly different from the questions for the builders (see Appendix 4). However, the first section which focused on the background of the participants and their company were similar for all groups of participants. The main questions for all the industry experts revolved around their relationship with the building firms and the other actors in the construction industry, as well as their function in facilitating or influencing them to become involved in environmental-friendly practices.

In addition, a number of specific questions were asked to each expert according to their work role. For instance, the questions for the architect were focused on their role

in designing a construction project which is the crucial part of starting and implementing a project. How they could influence the other project members especially builders, was the focal point of a number of questions. These kinds of questions needed to be addressed as they were raised by some of the respondents from the survey and the interviews with the builders as well. For the FMB, the interview questions were focusing more on its role as a source of knowledge for its members. While not all of the respondents, even from the survey or the builders who participated in the interviews are the member of FMB or other trade associations, the advantages of being a member of particular trade association are something that needed to be understood. As some of the builders who are the members of particular trade association could see the value of being the member, the answer of why the others could not see it needed to be found out. This issues closely related to the role of FMB itself as one of the source of information to assist builders in becoming environmentally-friendly in their work.

The questions for the other industry experts such as from ECCI, CSIC, Zero Waste Scotland and the Building Standard Division were specifically focused on their efforts towards minimising the environmental impacts and how they influenced the construction industry. For the environmental engineer, on the other hand, the questions were more on the representative's opinion about the state of the construction industry in relation to the environmental awareness and the extent of the industry actors' (specifically the builders') engagement in environmental-friendly practices.

However, the arrangement and the main ideas of the interview questions only served as a guide, the interviewer was free to ask any questions in any order as appropriate, and based on responses from the respondents to particular questions. This was the main difference between the survey and the interview questions. An interview allows the interviewer to go deeper and further on certain questions of interest by asking some follow-up questions to get into greater details. In addition, the general findings from the survey were also discussed with the interviewees in order to get their outlook on what happened in actual situations they were familiar with compared to the outcomes from the survey. The similarities and the differences in findings between the two

perspectives; survey and interview, would provide better insights on the issues investigated.

3.4.4 Pilot Interviews

Before commencing a series of interviews to support the findings from the quantitative study, a pilot study was conducted to improve the data collection process (Yin, 2009). A pilot study which is known as a feasibility study, can also be considered as a small version of a large scale research project (Daniels & Cannice, 2004). It is an important task as ‘it might give advance warning about where the main research project could fail, where research protocols may not be followed, or whether proposed methods or instruments are inappropriate or too complicated’ (Van Teijlingen & Hundley, 2001:p.35). Therefore, it could assist in finding out the practical problems of the research procedure. Moreover, any local politics and problems that could create confusion during the actual research process could be revealed in early stage (Van Teijlingen & Hundley, 2001). The most important is, a pilot study could help in developing and testing particular research instrument by trying it out (Baker, 1994), as undertaking it could help in reducing the risk of any potential problem that might occur using the proposed method in the future when it is deployed on a wider scale.

For the qualitative phase of this research, two pilot studies were undertaken in October 2014. They were selected based on access, convenience and geographic proximity (Yin, 2009). The recorded data obtained from the pilot study were transcribed and analysed appropriately as it was crucial for the subsequent rounds of the data collection. As a result, the pilot study highlighted certain areas of ambiguity within the questions which required further elaboration and explanation to help the respondent answer the posed questions. The output of the pilot study could assist in making various changes and alternations to the questions, some of the questions that were considered as irrelevant were eliminated while some other questions were prepared with some ideas to be elaborated to help the respondent understand particular questions. In relation to the issues of different companies with different levels of green innovation adoption (high and low level), two set of questions with slightly different approaches to questioning were used.

3.4.5 Interview Procedure

An informed consent statement form was given to the participants in the first place before starting the interview. It was to make it clear that those participants had control over the interview to a certain extent in terms of what information they wanted to provide. That meant the interviewer had to accept if there was some information that may need to withhold due to confidentiality issues. In addition, anonymity of the participants and their company was assured by agreed on the condition that the participant and their company's name remain confidential. This was to allow for further openness and a willingness to share all the information required. Overall, the participants were told that there was no risk in participating in the interview.

Thirteen interviews were conducted within four months. Six of these participants represented construction companies operating in Scotland which were selected based on predetermined criteria. The other seven participants were the industry experts that had direct and indirect relationships with the construction sector in general. Each of the 13 participants was interviewed once, with average duration of these interviews being 50 minutes. The interviews were conducted at their own offices to minimise disruption to the participants' working day.

Before starting the interview, it was made clear to the participants that the interview would be recorded for the purpose of minimising data loss and accurately transcribing the conversation. In addition, some notes would be kept in order to ensure that the discussion was captured in more than one way. The participants, then, were given a brief introduction on what the research as a whole was about.

Most of the questions were posed as set out earlier but some questions were asked in a slightly different order than set out so as to allow natural flow of the interview. In addition, some broad questions were requesting further points or opinion from the participants while some questions were seeking clarification from the interviewee. The interview was ended with an open section to allow any further points or opinions the participant wished to add. The purpose was to reveal out any further issues that were

not covered by the previous questions but were considered important to the participants. Shortly after every session of an interview, the audio recording was transcribed to ensure a comprehensive analysis of the information could be done while the discussion was fresh.

3.4.6 Qualitative Data Analysis

The interviews were transcribed between November 2014 and February 2015. The data transcription stage marks the beginning of the qualitative data analysis process in order to get acquainted with the data (Langdridge, 2004). The analysis was performed using one of the computer assisted qualitative data analysis (CAQDAS) programmes called QUIRKOS. Similar to established CAQDAS programmes such as NVIVO, ATLAS.ti, Ethnograph and Nudist, QUIRKOS is a new programme which also helps to manage, sort, organise and store qualitative data (Turner, 2015). It was introduced in 2013 by a team with a lot of experience in qualitative research using a variety of different approaches. The software has been designed based on needs of users which makes it easy to learn even for a first time user who has never used any other CAQDAS programmes before.

QUIRKOS in general, like other CAQDAS programmes, has advantages in terms of time saving, cost and convenience. In addition, each programme has its own advantage too. NVIVO, for instance, could assist in organising data starting from locating particular words or phrases to build a theory. QUIRKOS, on the other hand, has powerful coding and analysis tools that make coding quick and simple. Its user-friendly features allow the researcher to learn how to use it quickly and relatively easily (Turner, 2015).

Even though a CAQDAS programme could simplify data management, Weitzman (2000) argues that it lacks the rigour and analytical ability similar to a programme like SPSS. Aligned with that view, Dawson (2009) claims that while a computer can undertake various automated processes, it still cannot think about, judge or interpret qualitative data. She further states that, using CAQDAS grows a feeling of being

distant from the data, which is not the case if it done manually. Moreover, by using pen and print-outs, will keep the researcher in tune with the data which helps to captured details that a CAQDAS programme could omit.

Nevertheless, QUIRKOS is designed to be a 'best-of-both-worlds' for researchers who are familiar with qualitative software and researchers who are more comfortable with pen and highlighters. It has an interface that mimics the action of coding with highlighters while keeping researchers close to the data with live visual representations. Those were the reasons why QUIRKOS was considered instead of other CAQDAS programmes for analysing interview data collected in this research study.

3.4.6.1 Coding

The vital part of qualitative data analysis is 'coding' (Neuman, 1993). Coding data from interview transcripts is an important process to understand the meanings respondents attach to the phenomena under observation. Smith (2012; p46) defined 'coding' as 'the process of separating out ideas, so that themes or perspectives relevant to the research questions can be identified'. Codes are assigned to data normally in form of names or symbols to represent a group of similar ideas or phenomena. The process basically involves sorting the data into different parts by organising raw data into themes (Baralt, 2012) or standardised formats for analysis purposes (Gray, 2004), which will assist in interpreting the data. This technique was used to analyse data collected for this study.

Specifically, interview records were examined carefully to find out the categories or main themes. In order to conduct substantial analysis of the data, a six-step guideline proposed by Smith, Flowers and Larkin (2009) was used. It includes: (1) reading and re-reading, (2) initial noting, (3) developing emergent themes, (4) searching for connections across emergent themes, (5) moving to the next case, and (6) looking for patterns across cases. Once the patterns were identified, they were tested through an analytic audit process (Smith, 2004). At this stage, the patterns in the data were then clustered into a thematic structure, so as to permits identification of the superior

themes. Further, the interview texts and emerging themes were reviewed. This practice demonstrates the data triangulation model, and hence contributes to the credibility of the analysis.

From the analysis, two main themes were identified: (1) drivers of green innovation adoption, and (2) hindrances to green innovation adoption. The themes were developed in the form of a phrase. Based on the advice from Smith et al. (2009), the themes were intended to be concise and compressed, but at the same time still expressive enough to remember the original sources from which the themes had emerged. While I retained the original data sources, I also allowed myself to be guided by the research questions and literature, to be certain that these themes are addressing the research questions. The main themes were based on sub-themes, but at the same time, they were guided by theoretical knowledge. Specifically, each main theme was divided into two sub-themes: (1) internal factors, and (2) external factors, which were organised chronologically so that they could be traced from which interview each came. The grouping was visually created using hierarchical node trees, as illustrated in Figure 3.4, so that the organisation and relationship of themes was clearly seen.

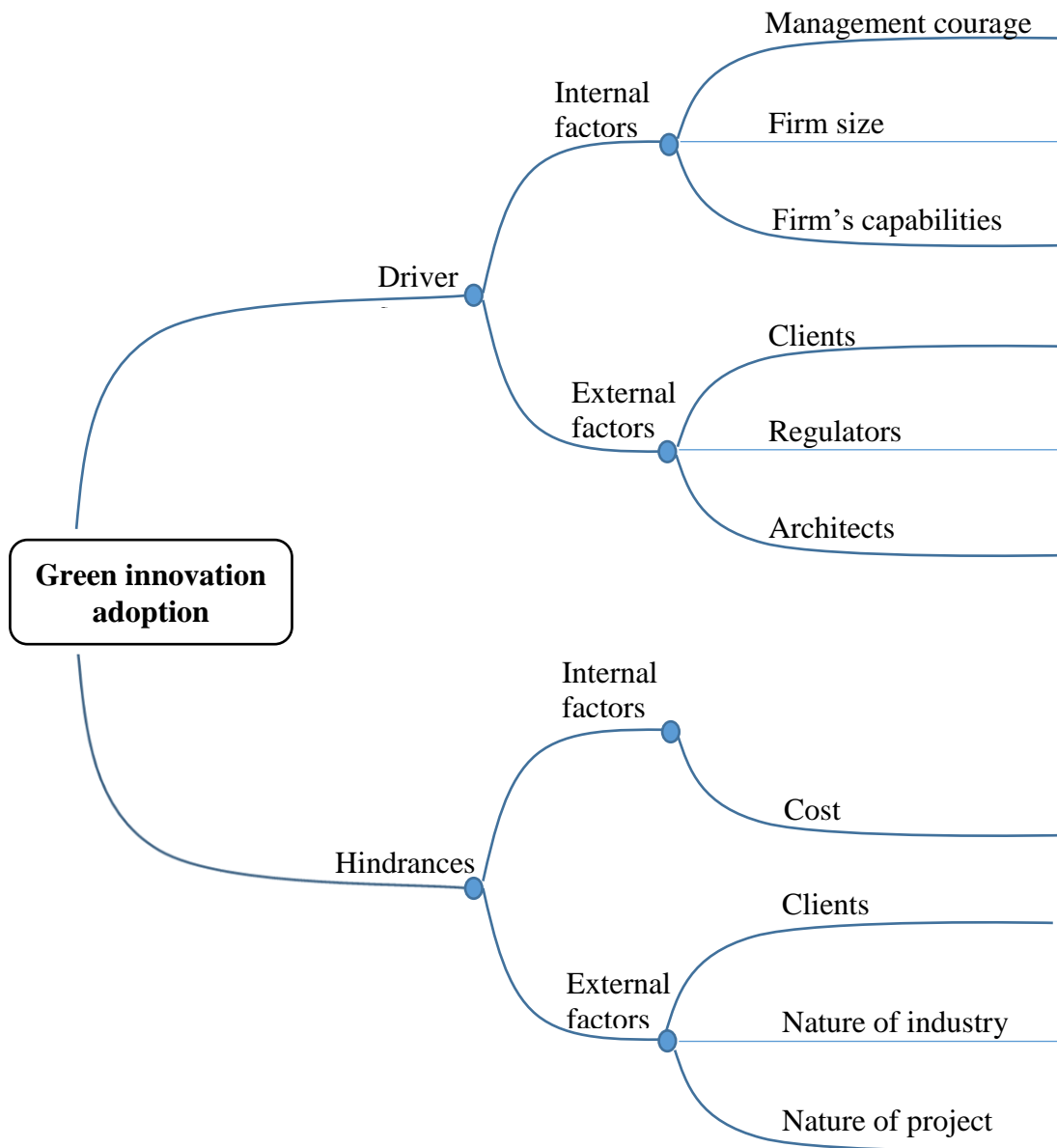


Figure 3.4: Emergent Themes

Each of the main themes, which was separated into more specific categories or sub-themes, represented different aspects of the main themes. For this study, appropriate themes and sub-themes were coded and established. Finally, examples of quotations from interviews which summarised and reflected each themes were included when presenting the data. A unique code for each interviewee is used to refer to all 13 interviewees in presenting the quotations from the interviews, as shown in Table 3.6.

Table 3.6: The Interviewees

	Companies/Bodies	Role	Code
Representatives of building firms	EC	Health and Safety Manager	CF1
	HC	Business Development Director	CF2
	JH	Business Manager	CF3
	GH	Managing Director	CF4
	WC	Director	CF5
	JE	Director	CF6
Representatives of the organisations within the construction industry	BW	Architect	IE1
	RSP	Environmental Engineer	IE2
	BSD	Head of Building Standard Divisions	IE3
	FMB	Scotland Director	IE4
	ZWS	Programme Area Manager	IE5
	CSIC	Business Relationship Manager	IE6
	ECCI	Executive Director	IE7

3.4.7 Validity and Reliability

In conducting a research study, whether quantitative or qualitative methods are used, ‘rigour’ is a desired goal to be achieved in order to avoid particular research becoming worthless, fictitious or losing its utility (Mertens, 1998). Therefore, a great deal of attention is applied to ensure ‘rigour’ in all research methods. In a general sense, ‘rigour’ is seen as the reliability and validity of research. Validity refers to the accuracy of research findings that could be extend beyond the specific setting in which the study was undertaken (Mertens, 1998), while reliability refers to the results of a study that are produced consistently over time in case the research is replicated (Joppe, 2000). A study with unreliable results cannot be valid. However, it is possible if a study has consistent results but is invalid as the research might not be measuring what it should be measured (Joppe, 2000). In qualitative studies, validity and reliability are subjective since the results emerge from socially constructed assessment, therefore, it is more appropriate to refer to them as credibility of a description, explanation, interpretation

or conclusion (Maxwell, 2005). In quantitative studies, these concepts are much easier to distinguish as they are more objective.

The importance of verification strategies should be considered throughout the research process in order to attain the validity and reliability, thus, 'rigour' of the study (Morse, Barrett, Mayan, Olson, & Spiers, 2002). As Morse et al. (2002) define verification is the process of checking, making sure, being certain and confirming, the mechanism is used by moving back and forth through the research process between design and analysis to ensure the data are systematically checked and maintained, where the process of analysis and interpretation are monitored and confirmed constantly. The appropriate use of verification strategies could drive the researcher to correct the direction of analysis as well as development of the study as necessary to help ensure validity and reliability of the completed study.

In order to ensure the validity and reliability of this study, a number of verification strategies were taken into account. Starting from the literature review phase until the interview sessions, data were gathered from available known sources. In addition, the interview questions were tested by conducting two pilot interviews to make certain in terms of clarity and consistency in delivering the questions on the part of the interviewer. Later, a coding system was developed to assist sorting the data for interpretation. This system was adjusted as new knowledge was acquired through interviews.

Recording the interviews and capturing notes comprehensively are other aspects of verification in attaining reliability. Research decisions in terms of background, resources, sampling and coding rules were documented. Transcribing data while still fresh also helped ensure reliable information. In addition, this study was used peer validation by made using of some colleagues for a second opinion in the transcription of interviewed data. This was done with the purpose of optimising the validity of the data (Creswell & Clarke, 2007). The entire data set was then analysed and converted into qualitative forms. Quotations of participants' interview were used as the evidence while a number of themes were created based on the literature. Along the process,

while unexpected findings happened to appear, they were incorporated into the conclusions which could provide further value for future research.

In general, it can be argued that this study fulfils the elements necessary to achieve the validity and reliability of a study.

3.5 Triangulation

In order to enhance the reliability and validity of collected data and its interpretation, triangulation was employed in this study. Olsen (2002; p.4) defines triangulation as ‘the mixing of data and methods so that diverse viewpoints or standpoints cast light upon a topic’. Triangulation is a technique used for double-checking or cross-checking data. In other words, it could enhance confidence in the ensuing findings. It can be done, for instance, by employing a number of different sources of data or combining several research methods to strengthen the insight gathered on the issues under study (Jick, 1979). It could help in improving and enhancing the validity of findings of a particular study, without relying on just one measure or method (Webb, Campbell, Schwartz, & Sechrest, 1966). Denzin (1978) distinguished four forms of triangulation technique, that is, data, investigator, theoretical and methodological, and these distinctions are summarised in Table 3.7.

Table 3.7: Triangulation Methods

Techniques	Distinctions between methods
Data triangulation	Several sources of data are used to gather a variety of data to collate and validate the phenomenon under study.
Investigator triangulation	More than one researcher in the particular field is used to collect and interpret data, this helps validate findings based on varied interpretation from different researchers.
Theory triangulation	More than one theoretical position is used to interpret data to understand the issues under study.
Methodological triangulation	More than one method is used to gather data to collate and triangulate the findings.

Source: Denzin (1978)

This study employed the methodological triangulation method. A survey was launched at first then while a number of interviews were conducted subsequently to gather further data. The ultimate purpose of using two different methods was to provide a more comprehensive set of findings which might not be arrived at through conducting one of the methods alone. In the other words, it provides a more complete picture of the phenomenon being studied.

In this study, the interviews were conducted to cross-check the findings of the survey. However, as the number of interviews is much lower than the number of survey responses; 13 compared to 84, the findings of both methods could not be compared directly. What can be best done is using the findings of the interviews to cast light on different areas and what might be underlying the survey findings.

3.6 Concluding Remarks

This chapter has highlighted the research methodology for this study. It has discussed the research stance in terms of philosophy and research method involving both quantitative and qualitative methodologies. With regard to the specific research methods for data collection, questionnaire survey and interviews were employed. In conjunction with that, survey and interview preparation, sampling procedures, data gathering execution, as well as validity and reliability matters for both quantitative and qualitative approach were discussed.

The following chapter presents the results of analyses undertaken on the quantitative data to assess the level of green innovation adoption and its relationship with a firm's absorptive capacity. The statistical analysis techniques used to analyse the survey were also discussed in the chapter.

CHAPTER FOUR: QUANTITATIVE DATA ANALYSIS AND RESULTS

4.0 Introduction

This chapter discusses the analysis on the collection of data through the questionnaire survey and interviews. The data collection process took approximately seven months in total for both the quantitative and qualitative phases. As outlined earlier, the survey questionnaire comprised six sections. The first two sections inquired after the general information about the respondents and their firms. Sections three to five contained questions that linked to the absorptive capacity dimensions. Meanwhile, the final section consisted of the measurement of green innovation practices, as well as questions regarding environmental requirements from regulators and clients. In terms of qualitative data, 13 interviews were captured using digital recordings which were transcribed later. After conducting the pilot interviews, the data collection tool was tested and modified at the necessary junctures for further improvement.

This chapter begins by reporting the procedure for the analysis of survey questionnaires, followed by a comprehensive discussion on the results. At the end of the chapter, a discussion on the descriptive data from the qualitative study, particularly regarding the profile of the participants in the interviews, is reported.

4.1 Statistical Procedures and Analyses for Quantitative Study

By referring to the questionnaire (Appendix 2), most of the questions that were related directly to the variables investigated in this study were using scale data. In contrast, general questions regarding the respondents and their firms were mainly using nominal data. Therefore, a number of different statistical procedures were employed to analyse the different types of data, starting with factor analysis, analysis of variance (ANOVA), and t-test. This was followed by basic descriptive statistics and more intricate procedures like multiple regression analysis.

Factor analysis was employed to examine the underlying structure among a number of variables (Hair et al., 2007). This analysis yielded a set of underlying dimensions that would be used in further analysis, including multiple regressions. A detailed discussion of the factor analysis procedure and results will be reported in the next subsection.

Furthermore, ANOVA was used in order to identify any difference among the three groups of respondents. As discussed previously, the respondents of this study consisted of representatives of building firms which had been identified from three different sources, namely the FMB directory, websites, and an annual local business directory. Thus, the scores of these three different groups of respondents needed to be compared to ensure that the data were appropriate for this study. In addition, a t-test was conducted to test if the non-response bias had a particular influence in this research by comparing the differences between early and late responses.

The descriptive statistics were then used to describe the measures of central tendency such as mean, median and mode as well as the measures of spread including variance and standard deviation. Pallant (2013) explained that this type of analysis was conducted to describe the basic features of the data using simple graphic analysis in order to develop a detailed understanding of the nature of the data.

Another useful technique that was adopted to analyse the quantitative data was multiple regression analysis. Pallant (2013) claimed that this is the most appropriate technique that allows the examination of the relationship between multiple independent variables and a dependent variable. Once the researcher manages to identify the way in which these multiple variables relate to the dependent variable, information about all the independent variables can be used to make more accurate prediction about them (Hair et al., 2007). This statistical procedure was used particularly to test a number of hypotheses that had been discussed in Chapter Two. The multiple regression equation used is as follows (Pallant, 2013):

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \varepsilon \quad (1)$$

Where

Y = Value of the dependent variable (Y), which is the item being predicted

a = Alpha is the constant or intercept

b_1 = Slope (Beta coefficient) for X_1 , the change in Y for each 1 increment change in X_1

X_1 = First independent variable (X_1 score) that explains the variance in Y

b_2 = Slope (Beta coefficient) for X_2 , the change in Y for each 1 increment change in X_2

X_2 = Second independent variable (X_2 score) that explains the variance in Y

b_3 = Slope (Beta coefficient) for X_3 , the change in Y for each 1 increment change in X_3

X_3 = Third independent variable (X_3 score) that explains the variance in Y

ε = Prediction error (residual)

Specifically, hierarchical multiple regression analysis was performed to examine the ability of two moderators, namely regulatory and customer pressures, to predict the adoption of green practices among the construction firms in Scotland. In order to achieve this objective, the two moderators and the three absorptive capacity factors – existing knowledge utilisation, knowledge building, and external knowledge acquisition – had been controlled. Accordingly, the hierarchical multiple regression equation used is as follows (Pallant, 2013):

$$Y = a + b_1X_1 + b_2X_2 + b_3(X_1 \times X_2) \quad (2)$$

Where in addition to previous equation

$(X_1 \times X_2)$ = Product term

Moreover, Figure 4.1 illustrates the types of statistical procedure performed for this research. The process of analysis and results of each statistical procedure will be discussed in detail later in the chapter.

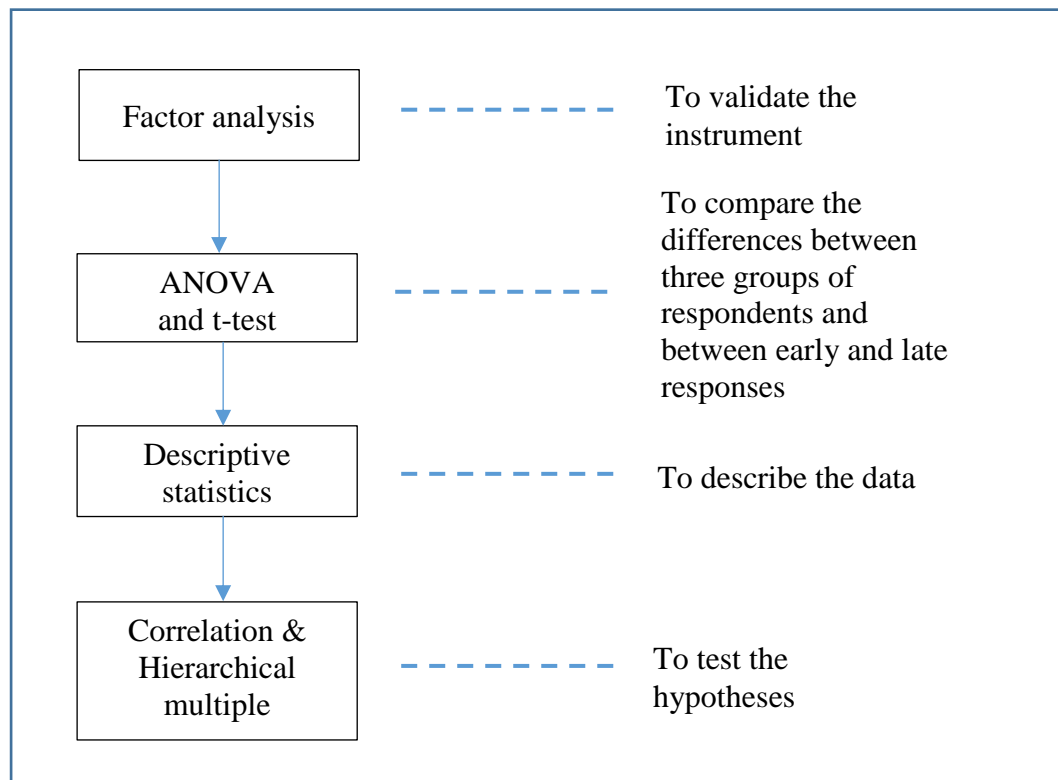


Figure 4.1: Statistical Procedure for the Quantitative Study
Source: Developed by the author.

4.1.1 Validity and Reliability of Instrument

Principal Component Analysis (PCA) was used to explore the underlying dimensions of the three sections in the survey questionnaire which covered the dependent, independent, and moderating variables, with the aim to validate the instrument. Known as one of the most commonly used exploratory data reduction techniques in the social sciences, PCA was performed to reduce the number of variables in a data set into a smaller number of 'dimensions' (Hair et al., 2007). PCA is similar to another technique called factor analysis (FA) in many ways, and researchers often use these two techniques interchangeably.

Although both techniques generally produce similar results (Arrindell & van der Ende, 1985; Velicer & Jackson, 1990a) several methodologists argued that PCA is a reasonable substitute for FA and is superior to the latter (Velicer & Jackson, 1990b,

1990a). They reasoned that the computation of PCA is easier than FA, and thus, requires less processing time and computer memory (Velicer & Jackson, 1990a).

However, there are a few issues related to PCA. In PCA, there are no available criteria against which to test the solution, as exist, for instance, in regression and analysis of variance (Velicer & Jackson, 1990b). Another issue that occurs frequently is the absence of available infinite number of rotations after extraction; this issue also happens in FA. As these techniques are commonly used to test the validity of the instrument in a study, researchers have to be very careful in their usage of both techniques. Apart from that, the selection of appropriate technique is essentially based on the goal of the particular analysis. If the goal is data reduction, as in the case of this study, PCA is more appropriate (Fabrigar, Wegener, MacCallum, & Strahan, 1999).

The procedure for conducting PCA can easily be obtained from most multivariate statistics literature (e.g. Hair et al., (2007). Prior to discussing the PCA procedure and results further, it is important to recall the structure of the questionnaire as shown in Table 4.1.

Table 4.1: Structure of the Questionnaire

Section		Number of items	Items
One (IVs)	Prior relevant knowledge (PRK)	4	PRK1, PRK2, PRK3, PRK4
	Communication climate (CC)	4	CC1, CC2, CC3, CC4
	Education and training (ET)	5	ET1, ET2, ET3, ET4, ET5
	Environmental scanning (ES)	6	ES1, ES2, ES3, ES4, ES5, ES6
	External linkages (EL)	7	EL1, EL2, EL3, EL4, EL5, EL6, EL7
Two (DVs)	Green technical innovation (GT)	3	GT1, GT2, GT3
	Green process innovation (GP)	6	GP1, GP2, GP3, GP4, GP5, GP6
	Green administrative innovation (GA)	5	GA1, GA2, GA3, GA4, GA5
Three (Moderators)	Regulatory pressure (RP)	4	RP1, RP2, RP3, RP4
	Customer pressure (CP)	4	CP1, CP2, CP3, CP4

For this study, one PCA was implemented for each set of variables. Thus, three PCAs were constructed, one for dependent variables, one for independent variables, and one for the moderators. The direct oblimin rotation method was conducted in the first place, as suggested by Tabachnick and Fidell (2007), then the correlation among factors need to be assessed to make further decisions. The results of the correlation value will then be used in deciding whether to remain with oblique or orthogonal rotation. In order to determine the number of components that should be extracted in PCA, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) based on eigenvalues more than one, was used along with an evaluation of Scree plots (Pett, Lackey, & Sullivan, 2003; Tabachnick & Fidell, 2007). The original dimensions were also taken into consideration while making the final decisions on the number of factors.

Based on the PCAs that have been conducted for each set of variables, the results show that the factor correlation matrix for dependent, independent and moderating variables is below 0.32, which means the correlations are not driven by the data (Tabachnick & Fidell, 2007). It shows that a very similar solution can be expected from the varimax rotation as the solution remains nearly orthogonal (Tabachnick & Fiddell, 2007). Therefore, the PCA was re-run by conducting varimax rotation since the orthogonal solutions are easier to interpret.

In order to determine whether the component model was appropriate, the Kaiser's measure of sampling adequacy (MSA) and Bartlett's test of sphericity were reported (Kaiser & Rice, 1974; Pett et al., 2003). MSA is a summary of how small the partial correlations are relative to the ordinary correlations. Small values of MSA indicate that the correlations between variable X and the other variables are unique, that is, not related to the remaining variables outside each simple correlation. Kaiser has described MSAs above 0.9 as marvelous, above 0.8 as meritorious, above 0.7 as middling, above 0.6 as mediocre, above 0.5 as miserable, and below 0.5 as unacceptable (Kaiser & Rice, 1974). Thus, in this study, the MSA above 0.6 was considered as acceptable.

Bartlett's test of sphericity can be used to test the null hypothesis that the sample was randomly drawn from a population in which the correlation matrix of the survey items was an identity matrix. Larger values of Bartlett's test indicate greater likelihood that the correlation matrix is not an identity matrix and that the null hypothesis should be rejected. Thus, MSA and Bartlett's test of sphericity are both indications of whether the factor model is appropriate.

4.1.1.1 PCA Results for the Dependent Variables

The first eigenvalue test for the dependent variables suggested four factors that account for 65.43% of the variance. Kaiser's criterion (retain factors if eigenvalues are more than one) and the Scree plot were used to help decide on the number of factors to be retained. The number of original dimensions was also taken into consideration while making the final decisions of the number of factors. After considering the theoretical definition of the construct which reflect the number of the original dimensions, a further test was conducted by forcing to three factors which explain 57.42% of the variance. Then, the scree plot as shown in Figure 4.2 was examined and consequently, three factors were retained.



Figure 4.2: Scree Plot of Eigenvalue for the Dependent Variables

Table 4.2 shows the factor loadings of the 14 items for the three factors. The greater the loading, the more the variable is a pure measure of the factor. Cronbach (1951) suggested that the general rules (could also be based on researchers' preferences) of the loadings in excess of 0.71 are considered excellent, 0.63 are considered very good, 0.55 are considered good, 0.45 are considered fair, and 0.32 are considered poor.

Table 4.2: Summary of Factor Loadings for Varimax Three-Factor Solution for the Green Innovation Factors

Item	Factor loading		
	1	2	3
GA2	.892	.070	.111
GA1	.816	-.035	.172
GA5	.682	.122	.300
GA3	.605	.379	-.251
GA4	.550	.401	.049
GP3	-.039	.779	.036
GP4	.136	.774	.062
GP6	.182	.681	.331
GP5	.250	.591	.202
GP2	.093	.477	.349
GT2	.042	.300	.774
GT3	.136	-.015	.767
GP1	.107	.298	.678
GT1	.076	.069	.634

The results of the PCA suggested that the underlying dimensions of the 14 items were:

- Green technical innovation (GT): GT1, GT2, GT3, GP1
- Green process innovation (GP): GP2, GP3, GP4, GP5, GP6
- Green administrative innovation (GA): GA1, GA2, GA3, GA4, GA5

The Kaiser's MSA value was 0.732 and Bartlett's test of sphericity was significant ($p= 0.000$), indicating that this model was appropriate.

4.1.1.2 PCA Results for the Independent Variables

The first eigenvalue test for the independent variables suggested that eight factors explained 73.55 % of the variance. As the number of factors to be retained was not

clear, a series of PCAs with five-, four-, and three-factor were performed. At the same time, Kaiser's criterion, the scree plot, and the number of original dimensions were also taken into account while making the final decision on the number of factors. Notably, the scree plot is illustrated in Figure 4.3. The final PCA model was determined after the results from the three models – five-, four-, and three-factor – were compared.

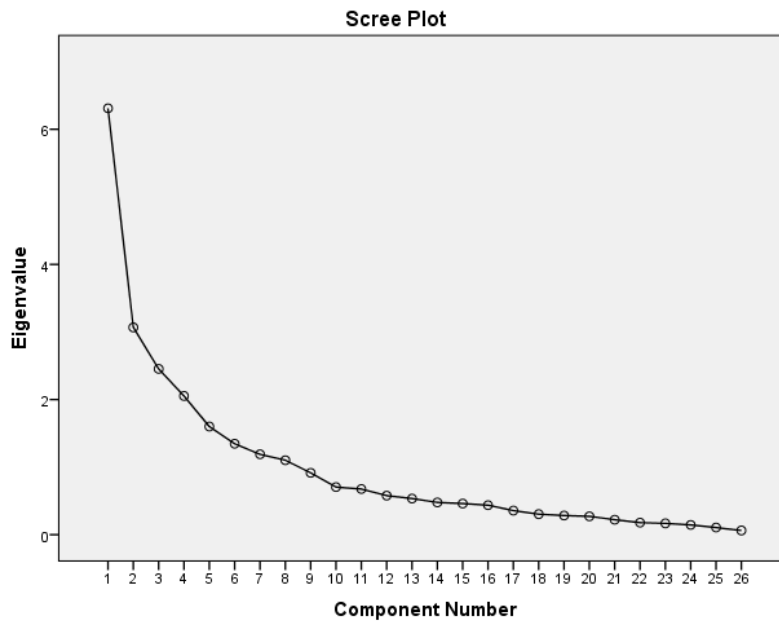


Figure 4.3: Scree Plot of Eigenvalue for the Independent Variables

For each PCA, the Kaiser's MSA = 0.703 and Bartlett's test of sphericity was significant ($p = 0.000$), indicating these three model were all appropriate. Although the three-factor model explained a lower portion of the variation, it was chosen as the ideal result in order to retain the dimensionality as close to the theoretical design of the survey questionnaire as possible. Under the three-factor model, four items, namely ES1, ES2, EL3, and EL6, appeared to have low factor loadings and, thus, were deleted. In addition, EL5 was also deleted due to cross loading and its difference from the rest of the items in the new subscale, despite the fact that it had a high factor loading.

In total, five items were deleted and this resulted in an increase in the MSA value to 0.714, whereas the total variance explained decreased to 51.02 %. The summary of

factor loadings for the three-factor solution of absorptive capacity is presented in Table 4.3.

Table 4.3: Summary of Factor Loadings for Varimax Three-Factor Solution for the Absorptive Capacity Factors

Item	Factor loading		
	1	2	3
ET2	.857	.170	.130
ET5	.830	.135	.122
ET3	.812	.107	.285
ET1	.788	.181	.034
ET4	.749	-.129	.275
PRK4	-.146	.747	.198
CC4	.090	.708	-.115
CC1	.152	.682	-.012
CC3	.257	.673	-.273
PRK3	-.052	.612	.339
CC2	.334	.592	-.067
PRK2	.095	.540	.094
PRK1	-.106	.467	.382
ES5	-.195	-.137	.754
ES4	.042	-.218	.660
ES6	.182	.089	.632
ES3	.282	-.053	.567
EL4	.318	.413	.557
EL1	.151	.198	.510
EL2	.116	.121	.455
EL7	.133	.050	.411

The three factors were labelled with new titles, namely existing knowledge utilisation (KU), knowledge building (KB), and external knowledge acquisition (KA). KU combined two original dimensions, namely PRK and CC, with a total of eight items. Furthermore, KB was the new title for ET which comprised the five original items. Meanwhile, KA encompassed the combination of ES and EL which contained eight items after deleting five items with low factor loading and cross loading. The new titles of the three factors are presented in Table 4.4.

Table 4.4: New Titles for the Three Dimensions of Absorptive Capacity

Original dimensions	New dimensions	Items
Prior relevant knowledge (PRK)	Existing knowledge utilisation (KU)	PRK1, PRK2, PRK3, PRK4, CC1, CC2, CC3, CC4
Communication climate (CC)		
Education and training (ET)	Knowledge building (KB)	ET1, ET2, ET3, ET4, ET5
Environmental scanning (ES)	External knowledge acquisition (KA)	ES3, ES4, ES5, ES6, EL1, EL2, EL4, EL7
External linkages (EL)		

4.1.1.3 PCA Results for the Moderators

The eigenvalue test for the moderators suggested two factors that explained 74.35% of the variance. After examining the scree plot as presented in Figure 4.4, two factors were retained.

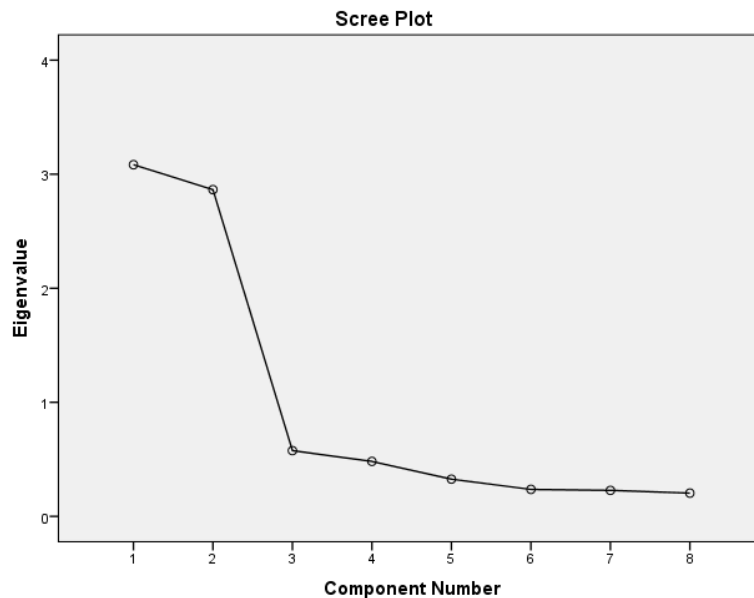


Figure 4.4: Scree plot of Eigenvalue for the Moderators

Table 4.5 outlines the factor loadings of the eight items under these two factors. The results of the PCA suggested that the underlying dimensions of the eight items were

- Regulatory pressure (RP): RP1, RP2, RP3, RP4
- Customer pressure (CP): CP1, CP2, CP3, CP4

Table 4.5: Summary of Factor Loadings for the Environmental Requirement Factors

Item	Factor loading	
	1	2
RP2	.906	-.052
RP3	.880	.036
RecodeRP4	.872	-.006
RP1	.832	.056
CP3	-.024	.895
CP2	.092	.860
CP1	-.086	.829
CP4	.055	.803

Notably, the two moderating factors had measured the underlying constructs with high validity as all of the factor loadings for the items were greater than 0.8. Moreover, MSA value was 0.779 and Bartlett's test of sphericity was significant ($p = 0.000$), indicating that this model was appropriate.

Based on the results of the PCAs, the final eight dimensions of the survey items are presented in Table 4.6.

Table 4.6: Summary of PCA Results for Dependent, Independent, and Moderating Variables

Variables	Dimensions	Items
Dependent variables	Green technical innovation (GT)	GT1, GT2, GT3, GP1
	Green process innovation (GP)	GP2, GP3, GP4, GP5, GP6
	Green administrative innovation (GA)	GA1, GA2, GA3, GA4, GA5
Independent variables	Existing knowledge utilisation (KU)	PRK1, PRK2, PRK3, PRK4, CC1, CC2, CC3, CC4
	Knowledge building (KB)	ET1, ET2, ET3, ET4, ET5
	External knowledge acquisition (KA)	ES3, ES4, ES5, ES6, EL1, EL2, EL4, EL7
Moderators	Regulatory pressure (RP)	RP1, RP2, RP3, RP4
	Customer pressure (CP)	CP1, CP2, CP3, CP4

After the underlying dimensions of the three sections of the survey questionnaire, dependent variables, independent variables, and moderators, were determined, Cronbach's Coefficient Alpha was used to examine the internal consistency of each factor to gauge its reliability (Johnson & Wichern, 1992). Cronbach's alpha is believed to indicate the degree to which a set of items consistently measure a single latent construct, and is an appropriate statistic for use in a particular study.

Table 4.7 shows the Cronbach's alpha for the eight dimensions. On the whole, the values of Cronbach's alpha ranged from 0.736 to 0.901; these figures were above the limit of 0.70 as suggested by Nunnally (1978). The general guidelines for alpha values are 0.90 to 1.0 is excellent, 0.80 to 0.89 is good, 0.70 to 0.79 is acceptable, 0.60 to 0.69 is questionable, 0.50 to 0.59 is poor, and below 0.50 is unacceptable (Tabachnick & Fidell, 2007). Nunnally (1978) indicated that newly developed measures can be accepted with an alpha value of 0.60, otherwise, 0.70 should be the threshold. Moreover, considering the use of these scales for the first time in a new culture, as in this study, the cut off value for the alpha coefficient was set up for 0.60 for all the scales (self-developed scales). Thus, the overall Cronbach's alpha values of above 0.7 for this study were considered acceptable to achieve the internal construct consistency.

Table 4.7: Cronbach's Alpha

		Number of items	Cronbach's alpha
Dependent variables	Green technical innovation (GT)	4	0.744
	Green process innovation (GP)	5	0.757
	Green administrative innovation (GA)	5	0.794
Independent variables	Existing knowledge utilisation (KU)	8	0.789
	Knowledge building (KB)	5	0.898
	External knowledge acquisition (KA)	8	0.753
Moderators	Regulatory pressure (RP)	4	0.891
	Customer pressure (CP)	4	0.867

The data collected by the instrument for this study, in conclusion, were valid and reliable. Therefore, further analysis could be performed to fulfil the intended aims. Accordingly, the descriptive data were explored followed by specific analysis to test the hypotheses.

4.1.2 Survey Response Rate

Out of the 392 questionnaires e-mailed to the FMB general builders in Scotland as listed in the final database, 29 e-mails were returned as undeliverable. This reduced the number of usable e-mail addresses to 363. The first approach for data collection generated a total of 49 responses which were achieved after three reminders were e-mailed to the non-respondents. Due to the low response rate from the first approach of data collection, additional invitations were e-mailed to 83 builders which had been identified earlier from the Internet. These builders were filtered from a large number of construction companies in Scotland through an intensive search on the Internet to fulfil the predetermined criteria in selecting the sample for the survey. As 16 e-mails were undelivered, the number of usable e-mail addresses from this second phase of data collection was reduced to 67. At the end of the second data collection period, 18 usable questionnaires were received.

The researcher put more effort into increasing the response rate by making a number of visits to 28 construction companies within the City of Edinburgh and the surrounding area. During these visits, the purpose of the survey was explained and the potential respondents were asked to fill out the questionnaire. This approach managed to gather 12 usable questionnaires. The final effort to get more responses was done by sending invitation e-mails again to 28 construction companies from the second group of builders who were identified from the Internet that had been contacted previously. As a result, another five usable responses were received and they contributed to the overall number of the responses.

Nevertheless, the response rate was affected by a number of potential respondents who indicated their unwillingness to participate in the survey in their reply to the invitation e-mail. In total, 32 builders had mentioned the same issue hindering their participation,

namely lack of time. Heavy workload caused these builders to not be able to spare some time to complete the survey. As a whole, out of 458 invitations sent out to the potential respondents, 84 usable responses were received from all sources, indicating an 18.3 % response rate. This information is provided in Table 4.8.

Table 4.8: Response Rate

Approaches	Total	Deliverable	Undeliverable	Responses received
E-mail to the general builders (FMB members)	392	363	29	49
E-mail to the builders identified from the internet	83	67	16	23
Visits	28	28		12
TOTAL	503	458	45	84 (18.3%)

As the data collected in this study were sourced from three different groups of respondent, sampling bias may occur. In order to avoid this error, one-way ANOVA was conducted to compare the organisational characteristics in terms of firm size among all of the respondents from the first group (FMB general builders in Scotland), the second group (respondents identified from Internet search), and the third group (respondents who were visited personally). As shown in Table 4.9, the results yielded no significant difference in terms of the firm size $F(2,81) = 0.21$, $p = 0.81$ among the three groups.

Table 4.9: Means, Standard Deviations, and One-Way ANOVA for the Effect of Firm Size on the Three Groups of Respondent

	Firm size (number or full time employees)			
	<i>M</i>	<i>SD</i>		
FMB members (N = 49)	25.71	71.31	$F(2,81) = 0.21$	$p = 0.81$
Website (N = 23)	32.52	72.85		
Visit (N = 12)	38.58	27.49		

Consecutively, the non-response bias was evaluated using ANOVA to determine any presence of significant difference in the mean values of the three green innovation factors among the three groups (Armstrong & Overton, 1977). Table 4.10 outlines the results which revealed that no difference existed on any of the factors among the three groups at 5 % level of significance.

Table 4.10: Means, Standard Deviations, and One-Way ANOVA for the Effect of Green Innovation Factors on the Three Groups of Respondent

	FMB members N = 49		Website N = 23		Visit N = 12		F(2,81)	p
	M	SD	M	SD	M	SD		
Green technical innovation	15.31	3.02	15.57	2.54	16.58	2.15	1.01	.37
Green process innovation	19.67	2.85	19.13	3.45	18.67	3.39	0.61	.55
Green administrative innovation	13.00	4.08	13.25	3.66	13.75	4.18	0.18	.84

The response rate for the survey – 18.3% – was considered common amongst comparable construction management research (Bing, Akintoye, Edwards, & Hardcastle, 2005). Harbaugh (2002) supported this statement by claiming that the response rates for mail surveys have continued to decline to a point where the average is below 20 %. Moreover, as the respondents for this study were key individuals in the firm, they are known to be less likely to respond to mailed questionnaires than other people in the general population (Hunt & Chonko, 1987).

Due to the lack of comparable data from the non-responding firms, the comparison between the responding and non-responding firms was done by comparing the early responses with the late responses. This approach was suggested by Armstrong and

Overton (1977). The t-test procedure was conducted under the assumption that those who responded less readily resembled more closely the characteristics of the non-respondents (Zou, Andrus, & Norvell, 1997). As presented in Table 4.11, the results of this procedure revealed that there was no difference in the mean values of any factor studied among the groups at 5 % level of significance. This indicated that the database was considered appropriate for this study. Therefore, it can be concluded that the non-response bias did not have any particular influence in this research (Skarmas, Katsikea, & Schlegelmilch, 2002).

Table 4.11: Non-response Bias

Variables	Early response N = 53		Late response N = 31		<i>F</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Green technical innovation	15.47	2.99	15.71	2.45	1.66	0.71
Green process innovation	19.70	2.87	18.84	3.41	1.27	0.22
Green administrative innovation	13.21	4.07	13.13	3.78	0.00	0.93

4.1.3 General Information of the Respondents and Their Firms

Table 4.12 depicts the demographic characteristics of the 84 respondents for this research. Notably, most of the respondents were holding senior positions as almost 70 % were the Managing Director or Proprietor of the firms. In terms of familiarity with the firms, more than 75 % of the respondents had been working there for more than five years. Almost 90 % of the respondents were men, indicating men's dominance compared to women in the construction industry. This was aligned with the findings of previous studies (for example Byrne, Clarke, & Van Der Meer, 2005).

Table 4.12: Demographic Characteristics of Respondents ($n=84$)

Characteristics	<i>n</i>	%
Position		
Managing Director/CEO	40	47.6
Proprietor	16	19.0
General Manager	12	14.3
Project Manager	2	2.4
Technical Manager	1	1.2
Other	13	15.5
Period of working (years)		
Less than 1	6	7.1
1-5	14	16.7
6-10	24	28.6
11-15	13	15.5
16-20	4	4.8
21 or longer	23	27.4
Gender		
Male	75	89.3
Female	9	10.7
Age (years)		
20-29	4	4.8
30-39	14	16.7
40-49	30	35.7
50 and above	36	42.9
Education level		
Vocational/Technical school	13	15.5
High school	9	10.7
College	28	33.3
University degree or higher	34	40.5

In addition, a majority of the respondents were 40 years old and above (78.6 %). This was normal as senior position posts are normally held by persons with more experience, which can be represented by age. Most of the respondents held at least a college qualification; 40.5 % were holders of a university undergraduate degree or higher qualification.

Table 4.13 shows the characteristics of the respondents' firms. A majority of the firms had very small numbers of full-time employees, which ranged from one to four people (36.9 %), or more than 15 employees (35.7 %). Most of the firms had been established for a period between 11 to 25 years (35.7 %). The firms were mainly providing services to residential customers (35.7 %) who were normally served by small firms which had more of a focus on a single sector like the residential sector. Other firms

were providing their services to customers from a combination of sectors, namely residential and commercial (27.4 %), as well as residential, commercial and industrial (32.1 %). Apart from that, a majority of the firms were family businesses (76.2 %), and only 10.7 % of them were ISO 14001 certified.

Table 4.13: Firms' Characteristics ($n=84$)

Characteristics	<i>n</i>	%
Number of full-time employees		
Fewer than 5	31	36.9
5 to 15	23	27.4
More than 15	30	35.7
Age of company (years)		
Less than 10	28	33.3
10 to 25	30	35.7
More than 25	26	31.0
Industry sector		
Residential	30	35.7
Commercial	4	4.8
Residential and commercial	23	27.4
Residential, commercial and industrial	27	32.1
Ownership		
Non-family business	20	23.8
Family business	64	76.2
ISO 14001 certification		
ISO 14001 certified	9	10.7
Non-certified	71	84.5
In the process of applying for certification	4	4.8

4.1.4 Level of Green Innovation Adoption

4.1.4.1 Types of Green Practices

First, descriptive analysis was conducted to find out the frequency of adoption of each green practice that had been listed in the survey. A 5-point Likert scale was used by the respondents, with a rating from 'strongly disagree' (1), 'disagree' (2), 'neutral' (3), 'agree' (4) to 'strongly agree' (5) to rate their agreement with the statements that indicated their adoption of particular green practices.

This scale, further, was recoded into a two category group. Firms rating the scale at 1, 2 and 3 (disagree with the statements) show no adoption or involvement in particular

practices while firms rating the scale at 4 and 5 indicate their adoption of particular practices to some extent.

Table 4.14: Level of Adoption of Green Practices by Scottish Building Firms

	Adopt	Not adopt	Total (%)
Green technical innovation (GT)			
(GT1) Our company adopts the technologies of energy conservation	70.2	29.8	100
(GT2) Our company adopts the technologies/ processes of pollution prevention	76.2	23.8	100
(GT3) Our company adopts the technologies of noise controlling	60.7	39.3	100
(GP1) Emission of hazardous substances or waste during construction activities are monitored	79.8	20.2	100
Green process innovation (GP)			
(GP2) Our company utilises, integrates with or recommends adoption of site waste management plans	72.6	27.4	100
(GP3) Energy is used efficiently during construction	79.8	20.2	100
(GP4) Materials that require low energy to produce where possible are specified or used during construction	58.3	41.7	100
(GP5) Locally sourced materials are used for construction activities to reduce energy use for transport	76.2	23.8	100
(GP6) Natural environment is conserved during construction activities	83.3	16.7	100
Green administrative innovation (GA)			
(GA1) Our company adopts environmental auditing	20.2	79.8	100
(GA2) Our company undertakes environmental protective education and training	22.6	77.4	100
(GA3) Our company offers employee remuneration and promotion based on environmental initiatives/ improvements	3.6	96.4	100
(GA4) Our company promotes new activities or events for staff linked to environmental-related issues	22.6	77.4	100
(GA5) Our company provides written environmental documentation such as policies, a mission statement, rules or procedures to protect the environment	47.6	52.4	100

n=84

The adoption levels of green technical, green process, and green administrative practices of the 84 Scottish building firms are shown in Table 4.14. The results indicated that most of the firms had adopted four types of green technologies while undertaking construction work for clients. A majority of the firms (79.8 %) had monitored the emission of hazardous substances or waste during their construction activities. The technologies for pollution prevention were adopted by more than 76 % of the firms, followed by the other types of green technologies, namely technologies for energy conservation (70.2 %) and technologies for controlling noise (60.7 %).

In terms of green process, the percentages of adoption for five environmentally-friendly construction processes during construction work for clients were considerably higher. In terms of high levels of adoption, 83.3 % of the firms gave great attention to conserving the natural environment of the area surrounding the construction site while implementing construction activities. In addition, 79.8 % of the firms had used energy efficiently during construction. Conversely, the usage of low energy materials was small as only 58.3 % of the firms adopted this approach during construction work.

On the other hand, the adoption of green administrative practices by the 84 firms was relatively low. The results revealed that not more than half of the firms (47.6 %) had their own written environmental documentation. Moreover, only 22.6 % of the firms encouraged new environmental-related activities for their staff members and undertook environmental education and training. Furthermore, remuneration and promotion for employees based on their environmental initiative was the practice which had the lowest adoption rate (3.6 %).

Overall, more than half of the firms had adopted various types of green technical and green process practices during construction. However, green administrative practices were adopted and introduced less frequently as indicated by the relatively small percentages. The effects of firm size and age on the adoption level of green practices by the 84 Scottish firms were examined. These two factors had been selected due to their prominence within the construction industry.

4.1.4.2 Firm Size

It has been mentioned in the previous section that the respondents of the survey came from three sources; FMB members, respondents identified from Internet search and respondents who were visited personally. They all fall under small- and medium-sized firms. For the purpose of comparing the level of green innovation adoption by those firms, I have divided the respondents into three groups by size in order to acquire comparable numbers of respondents for each group. For this study, the firm size was classified into three groups based on the number of employees, namely (i) fewer than five employees, (ii) five to 15 employees, and (iii) more than 15 employees. Out of the 84 building firms, 31 (36.9 %) were small firms employing fewer than five people, 23 firms (27.4%) were medium-sized with the middle range number of employees between five and 15 people. Meanwhile, the remaining 30 firms (35.7 %) were larger firms with more than 15 employees. This information is presented in Table 4.15.

Observation of the categories highlighted that the levels of adoption of both green technical and green process practices were quite high; almost all of the practices under both categories were adopted by more than 50 % of the building firms. However, the green administrative practices received relatively low level of adoption by the building firms with percentages less than 48 %. Notably, one of its practices was only adopted by 3.6 % of the building firms.

In terms of green technical innovation, large firms were the highest adopters of the four types of practices compared to small- and medium-sized firms (refer to Table 4.15). Out of 30 large companies, 93.3 % of them focused on monitoring the emission of hazardous substances or waste during the construction activities, followed by adopting the technologies/processes for pollution prevention (86.7 %), technologies for energy conservation (80 %), and technologies for noise control (70 %). Furthermore, most small firms concentrated on monitoring the emission of hazardous substances or waste during the construction activities (74.2 %), whereas medium-sized firms focused more on adopting the technologies/processes for pollution prevention (73.9 %).

Table 4.15: Level of Adoption of Green Technical Practices Based on Firm Size

		Firm size (employees)							
		Less than 5		5 to 15		More than 15		Total	
		n	%	n	%	n	%	n	%
Green technical (GT)									
GT1	Adopt	19	(61.3)	16	(69.6)	24	(80.0)	59	(70.2)
	Not adopt	12	(38.7)	7	(30.4)	6	(20.0)	25	(29.8)
GT2	Adopt	21	(67.7)	17	(73.9)	26	(86.7)	64	(76.2)
	Not adopt	10	(32.3)	6	(26.1)	4	(13.3)	20	(23.8)
GT3	Adopt	18	(58.1)	12	(52.2)	21	(70.0)	51	(60.7)
	Not adopt	13	(41.9)	11	(47.8)	9	(30.0)	33	(39.3)
GP1	Adopt	23	(74.2)	16	(69.6)	28	(93.3)	67	(79.8)
	Not adopt	8	(25.8)	7	(30.4)	2	(6.7)	17	(20.2)
Total		31	(100)	23	(100)	30	(100)	84	(100)

The results presented in Table 4.16 revealed that all five environment-friendly construction processes had been adopted by a majority of the firms. Specifically, large and small firms seemed to adopt the practices more compared to the medium-sized firms. Both large and small firms had focused on the conservation of the natural environment (93.3 % and 83.9 % of the total number in each size category, respectively); efficient utilisation of energy (86.7 % and 83.9 % of the total number in each size category, respectively); and consumption of locally-sourced materials for construction (86.7 % and 80.6 % of the total number in each size category, respectively). Although a majority of the medium-sized firms adopted almost all types of green process practices, more than half of them did not use low energy materials for construction.

Table 4.16: Level of Adoption of Green Process Practices Based on Firm Size

		Firm size (employees)							
		Less than 5		5 to 15		More than 15		Total	
		n	%	n	%	n	%	n	%
Green process (GP)									
GP2	Adopt	24	(77.4)	14	(60.9)	23	(76.7)	61	(72.6)
	Not adopt	7	(22.6)	9	(39.1)	7	(23.3)	23	(27.4)
GP3	Adopt	26	(83.9)	15	(65.2)	26	(86.7)	67	(79.8)
	Not adopt	5	(16.1)	8	(34.8)	4	(13.3)	17	(20.2)
GP4	Adopt	20	(64.5)	11	(47.8)	18	(60.0)	49	(58.3)
	Not adopt	11	(35.5)	12	(52.2)	12	(40.0)	35	(41.7)
GP5	Adopt	25	(80.6)	13	(56.5)	26	(86.7)	64	(76.2)
	Not adopt	6	(19.4)	10	(43.5)	4	(13.3)	20	(23.8)
GP6	Adopt	26	(83.9)	16	(69.6)	28	(93.3)	70	(83.3)
	Not adopt	5	(16.1)	7	(30.4)	2	(6.7)	14	(16.7)
Total		31	(100)	23	(100)	30	(100)	84	(100)

On the other hand, green administrative practices had much lower level of adoption by all categories of firm size, as presented in Table 4.17. Out of the five practices, having written environmental documentation was the only practice that was stressed by large firms (73.3 %). In addition, the results indicated that small- and medium-sized firms had less involvement in green administrative practices compared with large firms. The practice that had been given the least attention by the three size categories of firms was employee rewards based on environmental initiatives and improvements. Particularly, more than 93 % of the firms did not adopt this practice.

Table 4.17: Level of Adoption of Green Administrative Practices Based on Firm Size

		Firm size (employees)							
		Less than 5		5 to 15		More than 15		Total	
		n	%	n	%	n	%	n	%
Green administrative (GA)									
GA1	Adopt	2	(6.5)	3	(13.0)	12	(40.0)	17	(20.2)
	Not adopt	29	(93.5)	20	(87.0)	18	(60.0)	67	(79.8)
GA2	Adopt	4	(12.9)	2	(8.7)	13	(43.3)	19	(22.6)
	Not adopt	27	(87.1)	21	(91.3)	17	(56.7)	65	(77.4)
GA3	Adopt	2	(6.5)	0	(0.0)	1	(3.3)	3	(3.6)
	Not adopt	29	(93.5)	23	(100)	29	(96.7)	78	(96.4)
GA4	Adopt	5	(16.1)	5	(21.7)	9	(30.0)	19	(22.6)
	Not adopt	26	(83.9)	18	(78.3)	21	(70.0)	65	(77.4)
GA5	Adopt	8	(25.8)	10	(43.5)	22	(73.3)	40	(47.6)
	Not adopt	23	(74.2)	13	(56.5)	8	(26.7)	44	(52.4)
Total		31	(100)	23	(100)	30	(100)	84	(100)

4.1.4.3 Firm Age

Further, the respondent firms had been categorised into three bands based on the firms' age since they were established. Firms that had been established in the construction industry for less than 10 years were considered as young firms (28), firms that had been set up for between 10 and 25 years were considered as established firms (30), while firms that had been established for more than 25 years were classified as mature firms (26).

Table 4.18 revealed that the majority of young, established and mature firms, respectively, have high level of adoption of certain types of green technical practices.

The firms with the highest level of involvement in green technical practices, which is mature firms, have mostly focused on monitoring of hazardous substances and waste as well (88.5%) and adopted technology of pollution prevention (76.7%). The established firms have rather adopted technology associated with energy conservation (76.7%), and monitoring the emission of hazardous substances and waste (76.7%). However, most of mature firms have preferred not to adopt the technology of noise control (53.8%) which instead has been emphasised by much greater number of the young firms (78.6%).

Table 4.18: Level of Adoption of Green Technical Practices Based on Firm Age

		Firm age							
		Less than 10		10 to 25		More than 25		Total	
		n	%	n	%	n	%	n	%
Green technical (GT)									
GT1	Adopt	18 (64.3)		23 (76.7)		18 (69.2)		59 (70.2)	
	Not adopt	10 (35.7)		7 (23.3)		8 (30.8)		25 (29.8)	
GT2	Adopt	21 (75.0)		23 (76.7)		20 (76.9)		64 (76.2)	
	Not adopt	7 (25.0)		7 (23.3)		6 (23.1)		20 (23.8)	
GT3	Adopt	22 (78.6)		17 (56.7)		12 (46.2)		50 (60.7)	
	Not adopt	6 (21.4)		13 (43.3)		14 (53.8)		33 (39.3)	
GP1	Adopt	21 (75.0)		23 (76.7)		23 (88.5)		67 (79.8)	
	Not adopt	7 (25.0)		7 (23.3)		3 (11.5)		17 (20.2)	
Total		28 (100)		30 (100)		26 (100)		84 (100)	

In terms of green process practices, Table 4.19 showed that the established and mature firms have been highly involved in adopting environmentally-friendly processes during construction compared with the young firms. They have been attentive to efficient utilisation of energy (86.7% and 84.6%, respectively), and natural environment conservation (83.3% and 96.2%, respectively). The young firms have emphasised more on the adoption of site waste management plans (78.6%).

Table 4.19: Level of Adoption of Green Process Practices Based on Firm Age

		Firm age							
		Less than 10		10 to 25		More than 25		Total	
		n	%	n	%	n	%	n	%
Green process (GP)									
GP2	Adopt	22	(78.6)	23	(76.7)	16	(61.5)	61	(72.6)
	Not adopt	6	(21.4)	7	(23.3)	10	(38.5)	23	(27.4)
GP3	Adopt	19	(67.9)	26	(86.7)	22	(84.6)	67	(79.8)
	Not adopt	9	(32.1)	4	(13.3)	4	(15.4)	17	(20.2)
GP4	Adopt	16	(57.1)	18	(60.0)	15	(57.7)	49	(58.3)
	Not adopt	12	(42.9)	12	(40.0)	11	(42.3)	35	(41.7)
GP5	Adopt	20	(71.4)	22	(73.3)	22	(84.6)	64	(76.2)
	Not adopt	8	(28.6)	8	(26.7)	4	(15.4)	20	(23.8)
GP6	Adopt	20	(71.4)	25	(83.3)	25	(96.2)	70	(83.3)
	Not adopt	8	(28.6)	5	(16.7)	1	(3.8)	14	(16.7)
Total		28	(100)	30	(100)	26	(100)	84	(100)

Conversely, most of the young firms have not adopted any types of green administrative practices, as shown in Table 4.20. However, most of the established and mature firms have only provided written environmental documentation for administrative matters (63.3% and 53.8%, respectively) instead of other green administrative practices.

Table 4.20: Level of Adoption of Green Administrative Practices Based on Firm Age

		Firm age							
		Less than 10		10 to 25		More than 25		Total	
		n	%	n	%	25 n	%	n	%
Green administrative GA)									
GA1	Adopt	1	(3.6)	8	(26.7)	8	(30.8)	17	(20.2)
	Not adopt	27	(96.4)	22	(73.3)	18	(69.2)	67	(79.8)
GA2	Adopt	6	(21.4)	7	(23.3)	6	(23.1)	19	(22.6)
	Not adopt	22	(78.6)	23	(76.7)	20	(76.9)	65	(77.4)
GA3	Adopt	0	(0.0)	2	(6.7)	1	(3.8)	3	(3.6)
	Not adopt	28	(100)	28	(93.3)	25	(96.2)	81	(96.4)
GA4	Adopt	5	(17.9)	7	(23.3)	7	(26.9)	19	(22.6)
	Not adopt	23	(82.1)	23	(76.7)	19	(73.1)	65	(77.4)
GA5	Adopt	7	(25.0)	19	(63.3)	14	(53.8)	40	(47.6)
	Not adopt	21	(75.0)	11	(36.7)	12	(46.2)	44	(52.4)
Total		28	(100)	30	(100)	26	(100)	84	(100)

4.1.5 The Association between Absorptive Capacity and Green Innovation Adoption and the Moderating Effect of Regulatory and Customer Pressures

Moderated regression analysis was employed as it is one of the methods that has been recommended to test interaction effects (Cohen, Cohen, West, & Aiken, 1983). Hierarchical multiple regression analyses were performed to examine the ability of regulatory (RP) and customer pressure (CP) to predict the adoption of green practices among the building firms in Scotland, after controlling for the three absorptive capacity factors, namely existing knowledge utilisation (KU), knowledge building (KB), and external knowledge acquisition (KA). To understand the relationship between these factors, three sets of hierarchical moderated regression analyses for each dependent variable were conducted.

Prior to conducting hierarchical multiple regression, preliminary analyses were conducted to ensure no violation of the assumptions of multicollinearity, normality, linearity and homoscedasticity. A sample size of 84 was considered sufficient given three independent variables involved in the analysis, as the minimum ratio of valid cases to independent variables should be at least 5 to 1 (Tabachnick & Fidell, 2007). The correlations amongst the independent variables were examined and are presented in Table 4.21. It reveals that none of the independent variables were highly correlated as the correlations between independent variables were weak to moderate, ranging between $r = 0.27, p < .05$ and $r = 0.35, p < 0.001$. In addition, the collinearity statistics have shown that the tolerance and Variance Inflation Factor (VIF) values were all within accepted limits, thus, showing that multicollinearity was unlikely to be a problem (Tabachnick & Fidell, 2007). Further, residual and scatter plots indicated the assumption of normality, linearity and homoscedasticity were all believed to have been met (Hair et al., 2007).

Table 4.21: Descriptive Statistics and Correlations

Variable	Mean (SD)	1	2	3	4	5	6	7	8
1 Green technical innovation (GT)	15.56 (2.79)								
2 Green process innovation (GP)	19.38 (3.08)	0.44**							
3 Green administrative innovation (GA)	13.18 (3.95)	0.29**	0.40**						
4 Firm size	29.42 (66.86)	0.33**	0.17	0.14					
5 Regulatory pressure (RP)	13.93 (3.43)	0.13	0.21	0.36**	0.05				
6 Customer pressure (CP)	12.48 (3.49)	0.05	0.23*	0.33**	0.01	0.02			
7 Existing knowledge utilisation (KU)	32.65 (3.56)	0.22*	0.43**	0.12	0.10	0.08	0.08		
8 Knowledge building (KB)	14.39 (3.87)	0.33**	0.35**	0.60**	-0.03	0.14	0.21	0.27*	
9 External knowledge acquisition (KA)	30.17 (4.01)	0.28*	0.30**	0.36**	-0.02	0.16	0.32**	0.15	0.35**

$n = 84$. All variables are measured using 5-point Likert scale (with the exception of firm size)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Multicollinearity can be a critical problem in moderated regression analysis. This happens when one factor is highly correlated with other factors that could lead to inflated standard errors which further might result in misinterpretation of the statistical significant of the regression results (Jaccard, Wan, & Turrisi, 1990). In order to reduce or prevent any potential multicollinearity, the “centering” method has been employed for all the independent variables and the moderators prior to conducting the analysis (Jaccard et al., 1990; Tatikonda & Rosenthal, 2000).

The hierarchical multiple regression analysis is conducted in five steps as shown in next three tables (Table 4.22, 4.23 and 4.24) for each dependent variable. In the first step, Firm Size was entered into the regression to control its possible influence. Then, two environmental pressure factors that are moderators (RP and CP), as well as three absorptive capacity factors (KU, KB and KA), were entered as a block. Next, two

interaction terms of KU with each of the moderators were entered at Step 3. In the next step, two interaction terms of KB with each of the moderators were entered into the regression. Finally, the two interaction terms of KA with each of the moderators were entered into the final block. The significant main effects would support Hypotheses 1, 2 and 3, while significant interaction effects would support Hypotheses 4 and 5. Models for each moderated variables for the three dependent variables are presented below.

Table 4.22: Hierarchical Multiple Regression (Green Technical Innovation)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	15.16***	15.16***	15.15***	15.19***	15.09***
Firm size	0.01**	0.01**	0.01**	0.01**	0.01**
Main effects					
Regulatory Pressure (RP)		0.03	0.03	0.04	0.09
Customer Pressure (CP)		-0.06	-0.06	-0.05	-0.03
Existing knowledge utilisation (KU)		0.08	0.08	0.08	0.05
Knowledge building (KB)		0.18*	0.18*	0.18*	0.17*
External knowledge acquisition (KA)		0.14†	0.14†	0.12	0.20*
Interaction effects					
KU x RP			0.00	0.01	-0.01
KU x CP			0.00	0.01	0.00
KB x RP				-0.00	-0.01
KB x CP				-0.02	-0.03
KA x RP					0.02
KA x CP					0.02
F for the step	9.77**	3.37**	0.01	0.28	1.63
F for the regression	9.77**	4.67***	3.42**	2.74**	2.60**
Adjusted R ²	0.10	0.21	0.19	0.17	0.19

Note: N = 84; †p<0.10, *p<0.05, **p<0.01, ***p<0.001.

The first set of hierarchical multiple regression analysis results, particularly for the first dependent variable that is Green Technical Innovation are shown in Table 4.22. It revealed that in Model 1, Firm Size contributed significantly to the regression model, $F(1,82) = 9.77, p < 0.01$ and accounted for 9.6% of the variation in Green Technical Innovation (GT).

Model 2 with the main effects accounted for significantly more variance than just Firm Size, R^2 change = 0.16, $p = 0.008$. Hypothesis 1(a), 2(a) and 3(a) argue that higher levels of KU, KB and KA are positively related to the adoption of green technical innovation. By looking at individual effects, only KB ($B = 0.18, p < 0.05$) and KA ($B = 0.14, p < 0.10$) have a significant effect in the model. Thus, the presence of knowledge building effort and high levels of external knowledge acquisition are positively related to the adoption of Green Technical Innovation, indicating that H2(a) and H3(a) are supported while H1(a) is not supported.

Models 3 to 5 include the interaction terms between RP and CP and the three absorptive capacity factors. H4a-c(i) and H5a-c(i) hypothesise that environmental pressure from (a) regulator and (b) customer respectively have positive moderating effect on the relationship between KU, KB and KA and Green Technical Innovation. However, Models 3 to 5 with the interaction effects indicate very small increments in variance indicating that there is no significant moderation between the two moderators (RP and CP) and the three independent variables (KU, KB and KA) on GT. Hence, H4a-c(i) and H5a-c(i) are not supported.

The second set of hierarchical multiple regression analysis results for the second dependent variable, that is Green Process Innovation, is presented in Table 4.23. It shows that Model 1 with only Firm Size entered into the first block did not significantly contribute to the regression model, accounting for only 2.8% of the variation in Green Process Innovation (GP).

In Hypothesis 1(b), 2(b) and 3(b), firms with greater KU, KB and KA are positively related to the adoption of Green Process Innovation. Nevertheless, the introduction of

the two moderators (RP and CP) and the three independent variables (KU, KB and KA) in Model 2 explained an additional 29% of variation in GP and this change in R^2 was significant, $F(5,77) = 6.63$, $p < 0.001$. Nevertheless, individually, only the main effects caused by KU and KB are significant in the model ($B = 0.29$, $p < 0.01$ and $B = 0.14$, $p < 0.10$, respectively). Therefore, high levels of existing knowledge utilisation and knowledge building are positively related to the adoption of Green Process Innovation. Hence, H1(b) and H2(b) are supported while H3(b) is not supported.

Table 4.23: Hierarchical Multiple Regression (Green Process Innovation)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	19.15***	19.20***	19.24***	19.24***	19.31***
Firm size	0.01	0.01	0.01	0.01	0.01
Main effects					
Regulatory Pressure (RP)		0.12	0.15†	0.16†	0.13
Customer Pressure (CP)		0.11	0.11	0.12	0.11
Existing knowledge utilisation (KU)		0.29**	0.28**	0.28**	0.30**
Knowledge building (KB)		0.14†	0.12	0.10	0.11
External knowledge acquisition (KA)		0.10	0.12	0.11	0.08
Interaction effects					
KU x RP			-0.05*	-0.04†	-0.03
KU x CP			-0.01	-0.01	-0.01
KB x RP				-0.02	-0.02
KB x CP				0.01	0.02
KA x RP					-0.00
KA x CP					-0.02
F for the step	2.38	6.63***	2.85†	0.37	0.45
F for the regression	2.38	6.06***	5.48***	4.38***	3.67**
Adjusted R^2	0.02	0.27	0.30	0.29	0.28

Note: $N = 84$; † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

As regards interaction effects in Model 3, H4a(ii) and H5a(ii) hypothesise that environmental pressure from (a) regulator and (b) customer respectively have positive moderating effect on the relationship between KU and Green Process Innovation. The regression model explained an additional 4.8% of the variation in Green Process Innovation and this change in R^2 was significant, $F(2,75) = 2.85$, $p < 0.10$. However, the negative and statistically significant coefficient of the interaction term between KU and RP ($B = -0.05$, $p < 0.05$), indicates that Hypothesis 4a(ii) is not supported, hence contrary to the study contention, firms with high levels of existing knowledge utilisation adopt less green process innovation when they experienced high pressure from regulator. On the other hand, there is no significant moderation between CP and KU, thus, H5a(ii) is also not supported. Further, H4b-c(ii) and H5b-c(ii) hypothesise that environmental pressure from (a) regulator and (b) customer respectively have a positive moderating effect on the relationship between KB and KA and Green Process Innovation. Models 4 to 5 with the interaction effects indicate no significant moderation between the two moderators (RP and CP) and the other two independent variables (KB and KA) on GP. H4b-c(ii) and H5b-c(ii) are thus not supported.

Finally, Table 4.24 shows the results of the third set of hierarchical multiple regression analysis for the third dependent variable that is Green Administrative Innovation. The results demonstrated in Model 1, Firm Size accounted for a very small percentage of the variance (0.8%) in Green Administrative Innovation (GA), thus, did not significantly contribute to the regression model.

Table 4.24: Hierarchical Multiple Regression (Green Administrative Innovation)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	12.93***	12.91***	12.90***	12.90***	12.91***
Firm size	0.01	0.01†	0.01†	0.01†	0.01†
Main effects					
Regulatory Pressure (RP)		0.30**	0.32**	0.32**	0.32**
Customer Pressure (CP)		0.22*	0.23*	0.23*	0.23*
Existing knowledge utilisation (KU)		-0.09	-0.09	-0.10	-0.10
Knowledge building (KB)		0.53***	0.52***	0.52***	0.52***
External knowledge acquisition (KA)		0.09	0.09	0.09	0.11
Interaction effects					
KU x RP			-0.02	-0.02	-0.02
KU x CP			0.01	0.01	0.00
KB x RP				-0.00	-0.01
KB x CP				0.00	0.00
KA x RP					0.02
KA x CP					-0.01
F for the step	1.69	15.40***	0.42	0.00	0.35
F for the regression	1.69	13.37***	9.98***	7.77***	6.42***
Adjusted R ²	0.01	0.47	0.46	0.45	0.44

Note: $N = 84$; † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

However, by adding the two moderators (RP and CP) and the three independent variables (KU, KB and KA) in Model 2, they explained an additional 49% of variation in GA and this change in R^2 was significant, $F(5,77) = 15.40$, $p < 0.001$. To test Hypothesis 1(c), 2(c) and 3(c), individual effects in Model 2 were examined. It revealed that only KB shows significant effect in the model ($B = 0.53$, $p < 0.001$). Therefore, the presence of knowledge building effort is positively related to the adoption of Green Administrative Innovation. Thus, H2(c) is supported while H1(c)

and H3(c) are not supported due to no significant moderation demonstrated in the results.

With regard to interaction effects, H4a-c(iii) and H5a-c(iii) hypothesise that environmental pressure from (a) regulator and (b) customer respectively have positive moderating effect on the relationship between KU, KB and KA and Green Administrative Innovation. Models 3 to 5 show that the change of R^2 does not achieve the conventional level of significance, such that, there is no significant moderation between the two moderators (RP and CP) and the three independent variables (KU, KB and KA) on GA. Hence, H4a-c(iii) and H5a-c(iii) are not supported. Overall results of the hypotheses are shown in Table 4.25.

Table 4.25: Hypotheses and Results Summary

	Green technical		Green process		Green administrative	
KU	H1a	No	H1b	** yes	H1c	No
KB	H2a	* yes	H2b	† yes	H2c	*** yes
KA	H3a	† yes	H3b	No	H3c	No
RP x KU	H4a (i)		H4a (ii)		H4a (iii)	
RP x KB	H4b (i)	No	H4b (ii)	No	H4b (iii)	No
RP x KA	H4c (i)		H4c (ii)		H4c (iii)	
CP x KU	H5a (i)		H5a (ii)		H5a (iii)	
CP x KB	H5b (i)	No	H5b (ii)	No	H5b (iii)	No
CP x KA	H5c (i)		H5c (ii)		H5c (iii)	

Table 4.25 shows that Hypotheses 1 and 3 are partially supported, while Hypothesis 2 is supported. Hypotheses 4 and 5, however, have no support. The possible reasons for these occurrences will be considered in detail in Discussion chapter.

Following the survey, a series of interviews was conducted with six respondents from building companies and seven construction industry experts to capture in-depth

information and explore issues in more detail. The discussion on the descriptive data of the interview respondents will be reported in the following sub-section.

4.2 Descriptive Data of the Qualitative Study

As reported before, this study employed a mixed methods design which used a survey and a number of interview as techniques of data collection. The survey was conducted to test the proposed hypotheses while the interviews were sequentially undertaken to get in depth information in addition to what had been obtained from the survey. By examining the qualitative data, the companies who participated in this study can be divided into two groups; the building firm representatives and the industry experts. Six building firms participated to represent the construction group, while another seven participants who were considered as part of the industry stakeholders, represent the industry experts group. In total, 13 participants have been interviewed in a series of separate interviews. The profiles of each builders and the seven industry experts is presented in Table 4.26.

Table 4.26: Profile of Interviewed Participants

Representatives of building firms						
	Company	Number of employees	Age of company	Industrial sector	ISO 14001 accredited	Member of trade association(s)
1	JE	6	43	Residential	No	Yes
2	HC	126	22	Residential & commercial	Yes	Yes
3	EC	103	10	Residential & commercial	Yes	Yes
4	JH	10	30	Residential & commercial	No	No
5	WC	8	7	Residential	No	No
6	GH	30	9	Residential	No	No

Table 4.26: Profile of Interviewed Participants (continued)

Representatives of the organisations within the construction industry		
Category		
7	BW	Architect
8	FMB	Construction trade association
9	ECCI	Innovation Centre (Edinburgh)
10	CSIC	Innovation Centre (Scotland)
11	ZWS	Government funded body to support Scotland's zero waste plan
12	BSD	Building Standards Division
13	RSP	Consulting Engineer

The participants of the interviews, particularly the construction firms, were fulfilled the predetermined categories within the construction industry. It should be recalled that the researcher was looking for companies that could represent three categories, that is, firm size (large and small), firm age (new and established) as well as ISO 14001 certified and non-certified companies. In addition, as some of the participants being the member of trade association, their point of views related to the membership and information on what they had gained from the membership could assist the researcher to relate it to some of the questions that had been asked in the survey in relation to this issue. Moreover, the interviews were conducted with willing participants from the survey in order to further investigate the responses to the survey.

The other seven industry experts, on the other hands, have been provided an additional point of views regarding the involvement of building firms in green innovation and practices. Their additional input had aided deeper understanding on builders' decision towards being 'green', while indirectly provided perspectives regarding the real world situation within the construction industry.

4.3 Concluding Remarks

This chapter offered a profile of the survey respondents as well as information regarding their involvement in green innovation practices. Before that, the entire construct of the questionnaire was validated and refined using factor analysis and internal consistency analysis. As presented by the results, it clearly shows that the survey instrument was valid and reliable.

Subsequently, several statistical techniques were used for the purpose of answering the research questions. Descriptive analysis was used to describe the descriptive data while correlation and hierarchical regression analysis were conducted to test the hypotheses. Next, the results of all those analyses were reported.

In addition, the profile of the interview respondents was presented as well. Further discussion on the interview findings will be presented in the next chapter. Also, both survey and interview findings will be thoroughly discussed to obtain the final results that could contribute to meaningful research conclusions, which will be discussed in the final chapter.

CHAPTER FIVE: DISCUSSION OF QUANTITATIVE FINDINGS AND QUALITATIVE DATA

5.0 Introduction

In the previous chapter, the statistical analyses and results of the survey were reported. In this chapter, the findings of the quantitative study are discussed in detail. As both a survey and interviews were used as the means of data collection to help address the research questions, the results from the quantitative survey are elaborated along with the materials gathered through the interviews. The discussion is structured in such way as to enrich and deepen understanding of the quantitative study. The findings will then be linked to the literature in order to determine whether they demonstrate some strands of alignment or differentiation. Finally, a summary of the findings will be presented.

5.1 Green Innovation adoption by Scottish Building Firms

A total of 84 building firms participated in the survey during the first phase of data collection. In addition, a total of six respondents were selected to represent predetermined categories within the construction industry were then interviewed in person to explore issues in more detail and capture in-depth information in addition to what had been gained from the survey. The building firms' level of adoption of green practices is examined and discussed in this section. Further, seven industry experts were also interviewed to obtain related information regarding the involvement of building firms in green practices, which provided a different point of view and perspective.

Three categories of green practices were highlighted in the questionnaire survey. Under the headings of green technical, green process and green administrative practices, the level of adoption of each practice under the three category was assessed. The list of green practices and the percentage of adoption of each by the respondents' businesses are presented in Table 5.1.

Table 5.1: Percentage of Adoption of Green Practices by Respondents ($n=84$)

Practices	Percentage
Green technical	
Technology of energy conservation	70.2
Technology/process of pollution prevention	76.2
Technology of noise controlling	60.7
Monitoring emission of hazardous substance and waste	79.8
Green process	
Implementation of site waste management plans	72.6
Efficiently used energy	79.8
Usage of local materials	58.3
Usage of low energy materials	76.2
Conservation of natural environment	83.3
Green administrative	
Adopting environmental auditing	20.2
Undertaking environmental protective education and training	22.6
Offering remuneration to employees for environmental initiatives/improvement	3.6
Encouraging environmental-related activities for staff	22.6
Having environmental documentation	47.6

The table shows the percentage of adoption of green practices by the 84 building firms in Scotland who participated in the survey. Generally, by looking at each category, green technical and green process practices have higher percentages of adoption compared to green administrative practices. In terms of green technical innovation, the building firms have been focused more on monitoring emission of hazardous substance and waste (79.8%). As regards green process innovation, it has shown the highest percentage of adoption by the building firms where most of them have been focused more on conservation of natural environment around the surrounding area of construction sites (83.3%). While the percentages of adoption of green administrative innovation were very low, the most commonly adopted practice by the building firms appeared to be documenting their environmental-related activities (47.6%).

In the following sections, findings are considered along with the evidence from the interviews where the detailed discussion for each category will be presented.

5.1.1 Green Technical Innovation

Normally, during implementation of a construction project, a number of related types of equipment (e.g. shovels, wheelbarrows) or technologies (e.g. concrete mixer, crane) will be used by the builders to carry out particular activities. Use of these tools, sometimes is considered necessary, as they will affect, to some extent, the efficiency of particular activities. Since most of the technologies that are used while undertaking construction work are closely related to the requirement linked towards building to specification, their adoption could not be avoided. The same goes for the environmental-related technologies, which used to mitigate the effect of construction activities on the environment. Also known as green technologies, they include technology that incorporate power saving mechanism (e.g. solar panels), technology that installed to conserve water (e.g. appliances that use low water pressure) and technology that fitted to control noise during execution of construction activities. The adoption of those technologies helps to lower the adverse impact on the environment while implementing construction activities.

When looking at the findings of the survey, it shows a reasonably high percentage of adoption of each green technology (more than 60%) by the building firms, while undertaking construction works for clients. The majority of the firms had monitored the emission of hazardous substances or waste during construction activities (79.8%), followed by the adoption of technology of pollution prevention (76.2%), technology of energy conservation (70.2%), and technology of noise controlling (60.7%). Overall, it shows that most of the builders have demonstrated their transition from using typical construction technologies to environmentally-friendly technologies (Huang et al., 2009). Also, this indirectly shows the increase in environmental awareness among the building firms, in terms of technology usage.

These findings were then explored further through examining the level of adoption of green technologies and practices by different sizes and ages of firm. Both firm characteristics, in general, could influenced a firm's intention to adopt any practices. Firm size and firm age are two firm-specific factors which are used in most studies of adoption behaviour (Karshenas & Stoneman, 1995), as both are shown to have an important bearing on the adoption decision (Baptista, 2000). While the larger firm has been argued as having more advantages, for instance, in terms of management structure and resources, compared to the small firm (Lepoutre & Heene, 2006), old firms have been claimed as having cumulative experience in business operation (Giunta & Trivieri, 2007), which could influence their adoption decision.

In order to examine the level of adoption of green innovation by the building firms based on firm size, three groups of firm size have been distinguished according to the number of employees, and the adoption findings are presented in Table 5.2. The three firm size groups consist of: 1) small (fewer than 5 employees), 2) medium (5 to 15 employees) and 3) large (more than 15 employees). This categorisation is created purposely for comparison of participant firms which originally fall under small and medium-sized firms.

Table 5.2: Percentage of Adoption of Green Technical Practices Based on Firm Size

	(Out of)			
	Small (%) <i>n=31</i>	Medium (%) <i>n=23</i>	Large (%) <i>n=30</i>	Total <i>n=84</i>
Green technical				
Technology of energy conservation	19 (61.3)	16 (69.6)	24 (80.0)	59 (70.2)
Technology/process of pollution prevention	21 (67.7)	17 (73.9)	26 (86.7)	64 (76.2)
Technology of noise controlling	18 (58.1)	12 (52.2)	21 (70.0)	51 (60.7)
Monitoring emission of hazardous substance and waste	23 (74.2)	16 (69.6)	28 (93.3)	67 (79.8)

The results of the survey show that, out of total adopters, most of the green technical practices were adopted by large firms. As expected, large firms which have been argued as having greater availability in terms of capital, appear more able to use any equipment or green-related technology when required. Moreover, as large firms are usually involved in medium to large scale projects, they mostly face greater issues or problems related to environment impacts resulting from their activities, which require them to find solutions or to try to reduce them by, for instance, using appropriate green-related technologies or tools. This is supported by one of the respondents, CF1, who was working in a large firm and focusing more on pollution prevention system/technology when he stated,

“We always look to reduce noise and dust emissions within the workplace and so we certainly be required within the working time to reduce noise, dust, any sort of dust we are creating. We look at equipment that we have, we look at any dust suppression or dust collection on the equipment we use and if not they will use extraction systems to minimise our dust”.

As findings from the survey have shown that the larger firms have higher levels of green technology adoption compared to their small firm counterparts, it also reflects the economic circumstance of the firms, where large firms have great availability of resources to adopt particular green technology. The economic circumstance, directly, plays a major role in firm's decision to adopt new or shift to better technologies. Adopting environmental-related technologies usually requires a large amount of investment, which is a constraint for small firms. Cost would be the most significant factor that concerned the small firms when deciding to become involved in green practices, especially to invest in green-related technology. Three respondents who worked in small firms noted the importance of cost. CF6 stated that, *“To be honest, it costs lots of money”*, a pointed echoed by CF4, who commented, *“From a cost point of view, I don't like throwing away money”*. CF5's observation pointed to the way in which the issue of cost is central to all aspects of his firm's business, as he mentioned, *“Everything is really cost-based, you know, all are cost-based”*.

This definitely has been described in a study by del Río González (2005) who found that, larger firms, who are having the availability in terms of financial and other resources, tend to adopt radical environmental technologies compared to their small firm counterparts, who, otherwise, are frequently facing a relative shortage of financial, as well as human and technical resources. He further claimed that, this situation (financial shortage) normally occurs within traditional sectors such as the construction industry. Simply put, a traditional sector is an industrial sector that heavily relies on manual labour and craft skills, that has existed for centuries (Spithoven, Clarysse, & Knockaert, 2011), which is mostly dominated by small-scale businesses. The results of this study reflect the constraints faced by the small firms within the construction industry on their ability to adopt green technology.

In addition, the findings of this study are in accordance with the previous studies, which have been undertaken within different industries. For instance, a study by Kelley and Helper (1999) found that the larger the firm in the manufacturing industry, the higher the probability of adopting new technology. Another study conducted by Parhi (2005) in the manufacturing industry has demonstrated similar findings. Meanwhile, a more recent study of IT adoption has shown that larger firms were found show an increased probability of IT adoption (Giunta & Trivieri, 2007). This, however, would likely not be a direct effect of size (Harrison, Mykytyn, & Riemenschneider, 1997), perhaps through particular advantage, for instance, having a considerable resource base to invest in new technology. Size also offers advantage of a large human resource base with specialist staff to oversee the adoption of particular green technology.

Further, the level of firm's experience within the industry in terms of firm age was assessed. The age of firm, in general, could be considered as a proxy for the accumulation of experience (Giunta & Trivieri, 2007). Firm age or experience, sometimes, drives particular firms to be involved in particular practices, while in some cases they hinder the adoption of particular practices. Previous study has shown that the length of time for which a business has been in operation affects the way in which the business adopts technology. This implies that age of the business may have an impact on the decision to adopt new technology (Baptista, 2000). The findings from

the survey regarding the level of adoption of green practices based on firm age are presented in the Table 5.3.

Table 5.3: Percentage of Adoption of Green Technical Practices Based on Firm Age

	(Out of)			
	Young (%) <i>n</i> =28	Established (%) <i>n</i> =30	Mature (%) <i>n</i> =26	Total <i>n</i> =84
Green technical				
Technology of energy conservation	18 (64.3)	23 (76.7)	18 (69.2)	59 (70.2)
Technology/process of pollution prevention	21 (75.0)	23 (76.7)	20 (76.9)	64 (76.2)
Technology of noise controlling	22 (78.6)	17 (56.7)	12 (46.2)	51 (60.7)
Monitoring emission of hazardous substance and waste	21 (75.0)	23 (76.7)	23 (88.5)	67 (79.8)

For the purpose of comparing the adoption of green practices among the building firms based on their age, three groups have been identified from the survey responses; 1) young (less than 10 years), 2) established (between 10 and 25 years), and 3) mature (more than 25 years). Again, this categorisation is created purposely for comparison of participants' firms in this study.

Based on the results of the survey, all three categories of firm have adopted certain types of green technical practices. The results also revealed that, in general, among adopters, the established and mature firms show higher percentage of adoption of green technologies (more than 76% of adoption of the majority of the green technologies) than young firms. In other words, firms with more operating experience in the industry tend to adopt more environmental technologies than their new counterparts with less experience. Specifically, the mature firms, who have demonstrated the highest level of adoption of green technical practices, have been focusing more on monitoring emission of hazardous substance and waste (88.5%) and adopted technology of pollution prevention (76.9%), while the established firms have

been adopted the technology associated with energy conservation (76.7%) and technology of pollution prevention (76.7%). Most of the young firms, however, have adopted the technology of noise controlling (78.6%).

These findings are in alignment with earlier studies which suggest that adopters of technologies tend to be older firms (Franz & Robey, 1986), based on some reasons including the ability of older firms to adopt technology following their great experience, which could facilitate them in assimilating a new process into existing operations (Evans, 1987), while having greater reserves of resources for the acquisition and maintenance of the technology (Raymond, 1985). Thus, as experience assists the firm's learning process, the level of involvement in particular practices will increase accordingly linked to the accumulation of experience.

Given that younger firms are still in the process of positioning themselves in the marketplace, while having less experience compared to older firms, their low levels of adoption of green technology only represents their current situation. As they improving their businesses and gaining experience through time, they are also placing emphasising on the environmental aspects in their long-term planning. This was described by one of the interview respondents (CF1), who was working with an established firm, as he stated that, apart from using the existing green-related technology,

"We are also looking at the longer term, looking at potential electrical vehicles, again that's the fleet manager looking at that to add what we've already had, also looking at putting an electrical charge point in the building for the vehicles so that's something in the longer term that we are working on as an environmental improvement to the business".

The qualitative findings describe the enthusiasm of the new or less experienced firms to demonstrate their effort towards business development and improvement through their planning of adopting more green-related technology in future. Even although the results from the survey have demonstrated that the older firms have a greater propensity for adopting green technology more than younger firms, existing empirical evidence on the link between firm age and technology adoption is varied. For instance,

there are a number of studies that support the current study such as in a study that was conducted by Chuang, Rutherford and Lin (2007). They found that firm age is one of the significant predictors of technology adoption among SMEs. Another study that showed the alignment with the current study is that conducted by Giunta and Trivieri (2007), where the findings show insignificant results of their attempt to test negative relations between firm age and technology adoption.

On the other hand, some studies have shown a converse finding, as in a study by Haller and Siedschlag (2011). The study indicates that younger firms are more likely to adopt new technology. Also, in a study conducted by Goode and Stevens (2000), they were unable to prove that older firms are likely to adopt new technologies compared to younger firms. The results suggest that greater experience is not one of the factors that affects technology adoption. Accumulated experience, rather, hinders older firms from adopting a technology as their strongly established ways of operating are blocking off their view to see the need for new technology. As argued by Christensen and Rosenbloom (1995), younger firms are more flexible to the introduction of new technologies, thus, more likely to adopt a new technology than an established firm. In addition, they probably are more ready to embrace innovative growth that comes with particular investment in technology. They are more open to new ideas as well as more alert to green issues from foundation, as they may have 'green' as part of their firm's mission, goals and objectives.

However, judging from the evidence above, the findings of this study have demonstrated the firms' experience, in terms of firm age, has influenced to some extent the decision to adopt green technologies, where older firms are generally the higher adopters of green technology.

5.1.2 Green Process Innovation

There are various activities involved in undertaking construction work or building a facility for clients. In order to translate a design into reality, every construction project which is started from preparing the construction site until inspection of the completed

building or facility has some sort of impact on the environment. For example, while undertaking site preparation and foundation work, activities such as clearing the rocks, debris or trees, to some extent, would change the physical appearance of the surrounding area of the site, which at the same time could damage the vegetation and disturb the stability of the soil. As these effects, in general, could be seen and witnessed, this might be one of the reasons of why the majority of building firms which participated in the survey have conserved the natural environment of the surrounding area of construction sites (83.3%) as shown in Table 5.1 in the previous section. This shows that the building firms were careful about the construction site where they were working and its potential effect on their neighbours, which are the basic things to be considered during construction. It was also stressed by CF2, one of the respondents from the interviews,

“You know that on the site that we are working on, we like to be good neighbours, a lot of the sites that we operate on we sign up for Considerate Constructors Scheme which looks at a range of things related to the environment, but also, how neighbour layout, how much disruption and its causes, this sort of things”.

Next, by looking specifically at the level of green process adoption based on firm size, the results of the survey indicated that, out of total adopters, large firms have shown the higher levels of adoption of most of the green processes compared to smaller firms. These levels can be seen in Table 5.4 as follow.

Table 5.4: Percentage of Adoption of Green Process Practices Based on Firm Size

	(Out of)			
	Small (%) <i>n=31</i>	Medium (%) <i>n=23</i>	Large (%) <i>n=30</i>	Total <i>n=84</i>
Green process				
Implementation of site waste management plans	24 (77.4)	14 (60.9)	23 (76.7)	61 (72.6)
Efficiently used energy	26 (83.9)	15 (65.2)	26 (86.7)	67 (79.8)
Usage of low energy materials	20 (64.5)	11 (47.8)	18 (60.0)	49 (58.3)
Usage of local materials	25 (80.6)	13 (56.5)	26 (86.7)	64 (76.2)
Conservation of natural Environment	26 (83.9)	16 (69.6)	28 (93.3)	70 (83.3)

Specifically, the survey results showed that the majority of large firms have highly conserved the environment of the surrounding area of the construction site (93.3%), used local construction materials (86.7%) and used energy in efficient manner while undertaking construction works for their clients (86.7%). However, when looking across categories, small firms have rather implemented site waste management plans, more than medium and large firms. As waste management is generally related to activities required to manage the waste from its inception to its final disposal, the common issues that are often linked to it include waste minimisation, reuse and recycling. Most of the respondents across size categories, during the interviews talked a lot about their waste management activities. Proper waste management, either formal or informal, is becoming an increasing concern of the building firms as it has been emphasised in the building regulation. More specifically, the building firms were mostly managing their waste through recycling, reusing and reducing the waste. Five out of six respondents mentioned this issue specifically. For example CF2 noted,

“Through reduce, reuse, recycle, say waste management plan, we’ve played each part on that. We segregate, sometimes we segregate skips to separate waste trims, we can demonstrate that we do get back from the waste companies the report, you know, to authorise and demonstrate how much we actually recycle”.

Another respondent also mentioned about waste recycling even though his company usually does not have individual skips to put the different materials in, due to the lack of space at domestic properties where they were working. CF1 stated,

“The current recycling company which is Central Recycling Limited in Bonnybridge, they take the skip away and they have their own facility for their recycle materials. We get a monthly breakdown of each skip that we take and we get a monthly report for each site and the skip”.

This was echoed by other respondents who have focused more on reducing and reusing waste. As CF3 described,

“We reduce the waste as far as possible. I guess there’s waste from the demolition part of it and there’s the waste from too much use of resources. If we happened to demolish a building, for example, we would try as far as possible to save materials from that, so, for example, if it’s a slate roof we are trying put that aside, so it can be reused, same with the timbers, if we can reuse it, we will do”.

Meanwhile, another respondent, CF5 stated, *“Any materials that come from one job we take into another, and we use it first rather than just throw things away”*.

However, there are some challenges with engaging in recycling effectively, which hinder the building firms, in general, from increasing their effort in recycling their waste. Even although his company keeps doing recycling, CF4 expressed his disappointment at the recycling procedures and processes employed within the construction industry,

“We recycle as much of our waste as we can. Unfortunately it’s not made easy. We were asking to get, we have three different skips for the different waste but I have to say that most of the waste goes into the mixed or on the ground skip. Because we just can’t, they won’t take the plastic, they won’t because it’s polluted with other things, they won’t you know they don’t want timber if it’s got nails in it. It’s very difficult to recycle”.

While waste separation and sorting are important for enabling effective recycling processes, these activities are considered as time consuming and would probably add unnecessary labour costs to the job (Revell & Blackburn, 2007). Manual sorting of waste is still a technique which is very much used by building firms before sending it for recycling, which is possible for companies that are involved in small projects, that is, small construction companies. On the other hand, a huge amounts of waste is thrown away due to the difficulty of organising the recycling process (Revell & Blackburn, 2007). However, as recycling is one of the common and easier ways to contribute to environmental protection, as well as to comply with relevant legislation, the building firms are hoping for some improvement of recycling management within the industry, as mentioned by CF4,

“I wish there were more support within the industry for recycling but it just does not seem to be. It’s strange about recycling, almost all of us have our waste now, we are throwing away quite a lot of waste but we know the recycling avenues have to be set up in construction which is a big waste producer, the avenues are not there, they just not there, not in Scotland”.

Other than the adoption of site waste management plans, the survey results also showed that the majority of small firms have used low energy materials (64.5%) more than their larger counterparts, while undertaking construction work. Natural materials

such as wood, which has low embodied energy¹², are used extensively by most of the builders (Kim & Rigdon, 1998). Wood is a renewable material, which is more sustainable when it is incorporated into building products. Moreover, it is a common building material which can be used in building almost any type of structure, besides being affordable for small firms.

In terms of firm age, the waste management practices as discussed above are mostly implemented by young firms (78.6%) compared to their older counterparts, as shown from the results of the survey in Table 5.5.

Table 5.5: Percentage of Adoption of Green Process Practices Based on Firm Age

	(Out of)			
	Young (%) <i>n</i> =28	Established (%) <i>n</i> =30	Mature (%) <i>n</i> =26	Total <i>n</i> =84
Green process				
Implementation of site waste management plans	22 (78.6)	23 (76.7)	16 (61.5)	61 (72.6)
Efficiently used energy	19 (67.9)	26 (86.7)	22 (84.6)	67 (79.8)
Usage of low energy materials	16 (57.1)	18 (60.0)	15 (57.7)	49 (58.3)
Usage of local materials	20 (71.4)	22 (73.3)	22 (84.6)	64 (76.2)
Conservation of natural environment	20 (71.4)	25 (83.3)	25 (96.2)	70 (83.3)

Overall, established and mature firms have been highly involved in adopting environmentally-friendly processes during construction compared with the young firms. While mature firms have been focused more on conservation of natural environment (96.2%) and used local materials in their construction works (84.6%), established firms have been attentive to efficient utilisation of energy (86.7%).

¹² Embodied energy refers to the total energy required to produce that material, including the collection of raw materials.

In the case of younger firms, since they are still relatively new in their business operations, they prefer to get involved in simple and easier practices such as waste management (78.6%), particularly reuse and recycling, as they often face barriers of limited resources (Vermeulen, 2005) as well as experiencing a liability of newness due to lack of knowledge accumulation (Stinchcombe, 1965). Supporting this finding, one of the respondents, CF3 stated,

“I guess the first thing that we do is we try to minimise waste, we reduce the waste as much as possible, waste from the demolition part and the waste from too much use of resources. If we happened to demolish a building for example, we would try as far as possible to save materials from that so it can be reused, to reconstruct a new part of the building”.

However, when looking across the age categories, older firms (established and mature firms) have shown a higher levels of adoption of most of green processes. Some of the green process practices are highly adopted by mature firms. One of the practices, that is, the utilisation of local materials, requires a firm to have established relationships with resource providers, as well as lots of experience in handling construction materials, which are characteristics often linked to older firms. This result seem to be consistent with other research which found that as firms accumulate more experience and become more efficient in utilising their existing knowledge, they are more likely to get involved in more exploitive innovation activity (Benner & Tushman, 2003). This is reflected by a statement from CF2 who was working in a mature firm,

“We get involved a lot, making sure we are buying local, that we are employing local staffs, keeping our carbon footprint down a bit, monitoring energy consumption, it’s great and interesting”.

The adoption of those green processes, to some extent, has given some advantages to the particular firms to reduce the environmental impacts to the environment resulted from their activities. For example, they would be able to reduce their carbon footprint, manage their energy consumption effectively and reduce their construction waste.

Judging from the evidence above, the findings of the study have shown that the larger and older firms are more likely to adopt green processes than their smaller and younger firm counterparts. As larger firms have more availability in terms of resources to adopt

green processes as discussed in previous section, older firms, with cumulative experience in business operation are more ready to respond to innovation activities than younger firms, which is opposite to finding of studies conducted by Withers, Drnevich and Marino (2011), and Huergo and Jaumandreu (2004) who found that innovation activity is more likely to take place in entrant firms and firms at intermediate ages.

The following section will discuss further on the level of green innovation adoption among the building firms, in particular, the adoption of green administrative innovation.

5.1.3 Green Administrative Innovation

Generally, in terms of innovation adoption, managers justify their decisions based on the perceived economic and financial benefits (Rogers, 2003). However, managers are under pressure to adopt particular types of innovation in order to gain social legitimacy (DiMaggio & Powell, 1983), thus, they have to put aside their desire towards financial gain. While Abrahamson (1991) agreed with the statement and suggested that firms follow the trend to adopt even ineffective innovations, surprisingly, the results from the survey have shown the other way round, as presented in Table 5.6 and Table 5.7.

Administrative innovation can be categorised under the type of innovation that is not directly providing economic and financial benefits to the firms. Yet, by adding the innovation effort towards environmental protection, the adopter might have to spend more. In this study, the 84 building firms, either small or large firms, or new or established firms, have shown relatively low levels of adoption of all five green administrative practices.

Table 5.6: Percentage of Adoption of Green Administrative Practices Based on Firm Size

	(Out of)			
	Small	Medium	Large	Total
	(%)	(%)	(%)	<i>n</i> =84
	<i>n</i> =31	<i>n</i> =23	<i>n</i> =30	
Green administrative				
Adopting environmental auditing	2 (6.5)	3 (13.0)	12 (40.0)	17 (20.2)
Undertaking environmental protective education and training	4 (12.9)	2 (8.7)	13 (43.3)	19 (22.6)
Offering remuneration to employees for environmental initiatives/improvement	2 (6.5)	0 (0.0)	1 (3.3)	3 (3.6)
Encouraging environmental-related activities for staff	5 (16.1)	5 (21.7)	9 (30.0)	19 (22.6)
Having environmental Documentation	8 (25.8)	10 (43.5)	22 (73.3)	40 (47.6)

However, even though the overall percentages of adoption is low, the percentage of adoption of green administrative practices by large firms is higher than their small and medium firm counterparts. The adoption of administrative innovations or practices is closely related to organisational change as it involves, for examples, new management systems, administrative processes and staff development programmes (Subramanian & Nilakanta, 1996), which are the basis of implementation of the five practices listed in the questionnaire. In most cases, larger firms are more inclined to undertake organisational change because of their availability in terms of financial and other resources. This has been demonstrated by one of the large building firms which is actively providing environmental training to almost all of its employees, as discussed by CF2,

“They [the employees] have been on a range of different courses, some have been on very specific training, but some have been on quite more like, kind of a broad overview of environmental training”.

In addition, larger building firms are more systematic in monitoring their environmental performance compared to smaller firms. In other words, they have adopted their own environment auditing system, as stated by CF1,

“We certainly have started monitoring our environmental performance, the data we’ve got, five percent reduction on all the data we’ve got, but for water, gas, electricity, fuel, we’ve set five percent reduction on this year’s baseline and that will be reviewed annually, as we think it’s more achievable to increase that target to 10 or 15 percent, then we will do”.

Further, the results also revealed that based on both firm attributes, larger and older firms have higher percentage of having environmental documentation compared to smaller and younger firms, as can be seen in Table 5.6 and Table 5.7.

Table 5.7: Percentage of Adoption of Green Administrative Practices Based on Firm Age

	(Out of)			
	Young (%) <i>n</i> =28	Established (%) <i>n</i> =30	Mature (%) <i>n</i> =26	Total <i>n</i> =84
Green administrative				
Adopting environmental auditing	1 (3.6)	8 (26.7)	8 (30.8)	17 (20.2)
Undertaking environmental protective education and training	6 (21.4)	7 (23.3)	6 (23.1)	19 (22.6)
Offering remuneration to employees for environmental initiatives/improvement	0 (0.0)	2 (6.7)	1 (3.8)	3 (3.6)
Encouraging environmental-related activities for staff	5 (17.9)	7 (23.3)	7 (26.9)	19 (22.6)
Having environmental Documentation	7 (25.0)	19 (63.3)	14 (53.8)	40 (47.6)

The results are illustrated by two respondents who are working in large and older firms. CF1 commented on the link between legislation and firm policy, *“It is our policy to fully comply with environmental legislation. We have developed an*

environmental policy which outlines our commitment to the environment". CF2's response reflected his firm's long term perspective, noting, *"We are aware of our responsibility for the environment of future generations. That's why we have established our own environmental policy"*.

As larger firms are often found to be more active with respect to environment-related activities due to their financial and resource advantage than smaller firms (Ytterhus & Synnestvedt, 1996), they tend to have systematic environmental management approaches that require them to establish their own environmental policy in the first place. This is to demonstrate their environmental commitment. In terms of firm age, even though younger firms have been argued as more responsive (Calantone, Cavusgil, & Yushan, 2002; Thornhill & Amit, 2003) and likely to exploit environmental opportunities more often (Majumdar, 1997), the older firms have cumulative experience in their business operations, which would be able to direct them to be better, over time. It has been observed that with time, older firms discover what they are good at and learn to be more efficient (Thornhill & Amit, 2003). Adopting environmentally-friendly practices is one of the ways to improve their performance, which normally started with demonstrating their commitment through company ethos and policies.

Overall, when looking at the findings of the quantitative study, the levels of engagement of the building firms in green practices can be considered as relatively low. The evidence of the qualitative study which have been used to explore aspects of the findings of the quantitative study have strengthen the results of the survey. Most of the respondents firms do not have any goal or strategy related to the environment. Additionally, as the majority of the firms which operated in the construction industry are small and medium-sized firms, they are more focusing on profit to survive. Yet, they are operating in a traditional industry that is quite reluctant to change and does not easily receive new ideas.

A number of interviews with seven construction industry experts have presented some evidence relating to this. The experts were (1) an architect, (2) an environmental

engineer, (3) Head of Building Standard Divisions, (4) Scotland Director of Federation of Master Builder (FMB), (5) Business Support Manager of Zero Waste Scotland, (6) Business Development Manager of Construction Scotland Innovation Centre (CSIC), and (7) Executive Director of Edinburgh Centre for Carbon Innovation (ECCI). All those construction industry experts were base in Scotland and have been in the industry for 8 years in average. They were asked about the level of green innovation or practices adopted by Scottish construction firms. The first industry expert, IE1, mentioned,

“That’s one thing which I would say is in my experience, contractors aren’t interested at all in it. They just want to maximise their profit. There’s no business reason why they should do that. So I would say that, the building industry in general will do if they are told, they will do as they are regulated but in terms of them being positively interested or engaged in green issues, nope”.

IE2 also had a similar view, stating,

“They [builders] have involvement in that [green practices], their on-site activities consume energy, but there’s no real drive for them to reduce that. They have an involvement in designing green energy systems I suppose for buildings, but again there are very few contractors who will do their own design. I think there is still a long way to go”.

As green-related activities require a new and different way of practicing, IE2 added, *“If they [builders] have done something one way for a while, trying to change them to do something differently is quite challenging”.* When looking at wider perspective on the level of adoption of green practices by the Scottish construction firms, IE5 stated,

“Some construction companies are very progressive, some are not so progressive and still need to learn, some companies are good on some projects and not so good in others because they simply don’t have within the budget to do so, also there’s a challenge in many sites relating to space for segregating waste for example, or there are other financial challenges”.

Meanwhile, another industry expert had given his view relating to this by highlighting the factor of firm size. IE7 claimed,

“I think most of the bigger construction companies will complain about, they think the zero carbon levels are too high, the standards are too high, but they have all become better and better over the last 15 years or so, so I think they are all engaged in it one way or the other but like all industries, and particularly the building industry, because you have lots of very small building firms, percolating new ideas through that is much harder. It doesn't change very quickly, so it will always take a while for those ideas to percolate through into all the different firms. I think you have some leading ones who are very good and I think you have some laggards who are very slow”.

On the other hand, a generally positive statement was made by one of the industry experts relating to this issue. IE6 stated,

“I think they are getting much better, when I first started in this sector probably 10 years ago, there was nothing really in place, you didn't have service management plans, barely didn't have any KPIs, measuring anything, very little segregation of waste, building products, but now I think they are getting better”.

Those statements have shown that, to some extent, the Scottish construction firms have made a slow move in using or engaging in green-related practices. There is a sense here that things are changing in the industry. This is largely the case given how the industry is structured; where there are a lot of small firms which operate in the sector, which means it will take time to change. While the attitude of reluctance to change is synonymous with most of the small firms which operate in a traditional industry like construction, the limited capability and availability in terms of finance also has a direct influence on firms' engagement in green innovation (del Río González, 2005). The firms were struggling to pay for better construction activities which could contribute to the reduction of negative environmental impacts, not to mention their decision to adopt environmental-related innovation that set aside the profits gained through other developments such as via green administrative innovation. At the same time, there must be some reasons why the industry demonstrated such a trend. Therefore, the next section will discuss the factors which hinder the building firms from adopting green innovation.

5.1.4 Hindrances to Green Innovation Adoption

As the level of green innovation adoption among Scottish construction firms does not look particularly high at this moment in time, the industry experts were asked what is stopping the construction firms from adopting green practices. Most of the industry experts have identified the same main factor, which is cost, as hindering the firms from engaging in green-related practices. For example, IE1 stated, *“Green design or green practices have been something which add to the cost to the builders”*. While IE2 observed,

“Sometimes there is a cost premium to doing these things (green practices), why would we do that if we don’t have to, that might require us to appoint someone extra for that site, why would we want to do that if we are not being asked to do it? If it is not necessary why would you spend the time to do it because you’re probably not getting paid for it”.

Agreeing with the previous respondents, IE5 given his short and clear answer, *“Cost is a major factor”*. Another two industry experts had similar views. As mentioned by IE6,

“Whatever the cheapest way of doing something is, they will do, because they are cost driven, they are accountable to the stake holders, the shareholders, it’s very, very much cost driven”.

IE7, on the other hand, commented more specifically,

“Some of the new materials, one of the big challenges we have is that they cost a lot upfront, so even though the running costs are lower, and so overall the costs are lower, because there is a big upfront cost”.

These statements are seen as reflecting what is in the builders’ head, that cost is the main concern to them if they are deciding to adopt green practices. One of the building firm respondents, CF2, mentioned, *“Sustainability costs money. When it comes to sort of being more sustainable, kind of more environmentally-friendly, you pay a premium for them unfortunately”*. However, the construction firms, if they asked to, are willing to adopt any types of green practices if their client would bear the cost, as CF2 added, *“If the client has the budget for it, it’s the first thing that we go you know”*.

Voicing the same statement, another building firm respondent emphasised on their adoption decision, which is based on their preferences, when costs are involved. CF3 commented,

“The better environmental choice, quite often it makes economic sense for us to do that, but quite often with new technologies it’s gonna be more expensive, over cost I guess. So that not always could be our first choice”.

Another building firm respondent, CF4, has expressed his cynical view, relating to this by stating, *“I don’t buy and use those things [green-related product or practices], cost me almost ten times, don’t do anything different at all”.*

Responding to the question about why he was not using green practices in his business, another building firm respondent, CF5, summed things up in a single word, *“Cost”*. While most of the building firms agreed on one main factor that was stopping them from adopting green practices in their business, the industry experts came out with more factors that also could influence the construction firms to not to adopt it.

Green-related activities can be considered as a new practice to firms who have never been engaged with it before, which might need more attention and effort in order to ensure it can be done smoothly and the firms could get benefit from it. This is, however, a potentially undesirable act for them, as stated by one of the industry experts, IE2,

“The fact that if something has not been done before, then doing it for the first time is going to take time, it’s going to be a bit of a learning curve of course, and yeah, a slight reluctance to do things differently if it’s not absolutely necessary to do things that way”.

The above statement was confirmed by one of the building firm respondents, CF4, who mentioned, *“It takes me all my energy to skip our health and safety policy never mind the environmental one but I mean we do care about it”*. Understanding the benefits and the extent of the changes that would occur within the firm in relation to the adoption of new practices (e.g. green innovation), is a difficult challenge. This, further, requires concerted effort to make it happens. Due to the fact, most of the building firms were preferred not to adopt new practices.

In addition, the nature of thinking and acting of the majority of building firms who are focusing more towards profit, to a great extent, has influenced their interest in green-related activities or practices. This was mentioned by one of the industry experts, IE1, who noted,

“The builder and contractor will only do it [green practices] if they think if there is profit to be gained. Generally I would say that kind of major contractors, major house builders are impervious to anything apart from profit. But I would say that contractors have to be told what to do because if they didn’t they will just do the minimum”.

Moreover, most of the building firms feel comfortable working in their comfort zone, which makes them reluctant to change to new practice. Change, for them, means learning new skills and giving up the things they have been very good at, for years. Thus, this attitude could be one of the factors that is stopping them from adopting green practices, as mentioned by one of the industry experts, IE7,

“If you’ve been working with a particular material for 20 or 30 years and then somebody says, hey, look here’s a new material, do you immediately trust it? Not really. So until they’ve seen it in action, until they’ve seen other people putting it in place, they’re a bit dubious about that. They are very dubious about stuff that is being imposed on them by other people. So culturally they are just doing what they have always done”.

The perspective from the previous respondents was summed up by CF4, who stated,

“Generally tradesmen are quite old fashioned. If they learn how to build a house this way when they were 14 or 16, that’s the way they think it should still be built 20 years later. They don’t tend to want to change because generally change is more difficult”.

While some building firms were seen as being generally reluctant to change, probably fear of failure or proud of being very good at certain practices, this attitude has become a negative culture that is stopping them from adopting green practices. This culture has been immersed within the construction sector for a long time and became synonymous with the industry.

On the other hand, sometimes, it is not easy for building firms to adopt green practices when it comes to the types of building they are working on, whether it is a new house, retrofitting or trying to maintain current housing stock, as mentioned by one of the industry experts, IE4,

“In which case if you look at the conservation angle, there are many traditional buildings in Scotland and lots of building were built pre 1919. It’s important to preserve and maintain the existing buildings and make sure they are wind and water tight which I guess is the number one. So from that angle too, you can’t certainly go on and produce, make double glazing and ventilation [green products] in the building because the conservation laws would come into play”.

Scotland, as we know, has a lot of traditional beautiful buildings. Moreover, there is a lot of the existing building stock which is responsible for a significant proportion of CO₂ emissions and these buildings have been around for 100 years or more in many cases. However, it is not easy to preserve and maintain those kinds of building, in terms of improving the environmental footprint, for example, as they are subject to conservation laws. This limits the opportunity for the particular building firms to become involved in green practices.

These are some of the factors that could hinder the building firms from adopting green-related practices. As this study intends to investigate the relationship between firms’ absorptive capacity and green innovation adoption, knowing the other factors which could hinder the firms from adopting green-related practices, to some extent, could assist in deeper understanding of the green innovation context.

Further, in the next section, the second part of the quantitative findings will be discussed in detail, elaborating the role of absorptive capacity in influencing the adoption of green innovation by the building firms in Scotland, along with the discussion of qualitative findings on that topic.

5.2 The Role of Absorptive Capacity in Influencing the Adoption of Green Innovation

One of the main objectives of this study is to examine the role of absorptive capacity in influencing the adoption of green innovation by the building firms in Scotland. This section will discuss the findings of the quantitative study along with data which was obtained by undertaking interviews with six respondent firms and seven industry experts, to fulfil the particular objective.

5.2.1 Absorptive Capacity: Existing Knowledge Utilisation

As absorptive capacity is closely related to a firm's capability to utilise its existing knowledge, the first dimension of absorptive capacity, namely Existing Knowledge Utilisation (KU) has been examined by first looking at the competencies of the employees. The results of the survey in relation to KU are shown in Table 5.8.

Table 5.8: Summary of the Survey Results on the Relationship between KU and Green Innovation Adoption.

Hypotheses	Results
H1a: A higher level of a firm's existing knowledge utilisation is positively related to the adoption of green technical innovation	Not supported
H1b: A higher level of a firm's existing knowledge utilisation is positively related to the adoption of green process innovation	Supported
H1c: A higher level of a firm's existing knowledge utilisation is positively related to the adoption of green administrative innovation	Not supported

The results of the proposed hypothesis on the relationship between KU and the adoption of green innovation are partially supported. This happened probably due to a number of reasons. First, the firms' cumulative knowledge stock in terms of employees' competency and experience was not enough to influence the firms to become engaged in green innovation. As the existing knowledge base of a firm is strongly related to its employees, their qualification and competencies in a particular area is an important aspect of a firm's absorptive capacity (Minbaeva et al., 2003).

However, the firms need a sufficient number of qualified employees (Rothwell & Dodgson, 1991), who are more able in terms of accepting, assimilating and transforming available environmental knowledge (Vinding, 2006), which then would direct them to become involved in green practices.

The findings of the interviews with the building firms, however, have shown that the majority of the respondents have claimed that their employees are competent and qualified in their own area of work, showing the existence of the basic need for the development of absorptive capacity within the firms. For example, CF3 stated,

“All in our office are either all qualified professional tradesmen or are the apprentices. I mean all of our boys are tradesmen so they’ve all gone through whatever they have to do for the specific trades, the apprentices are obviously in the process of doing that, so I think they are, we’ve got a good team with us. I think they are probably very qualify in their own fields”.

CG4 stressed how competence and skills had played a role in hiring the right staff, *“I would say most of them are very, very good at their job and because I’ve chosen them because they are very, very good”*. The role of training to ensure staff had the right skills was evident in CF5’s comments,

“[They are] very, very competent. We have a team of excellent tradesmen. We’ve got a lot of experience and they all very well trained and they are all very nice people who treat customers nicely and also act nicely and the team is one of the main priorities, everybody’s nice”.

His observations also point to the importance of customer facing, interpersonal skills. Another respondent also emphasised about the qualification of the employees, which demonstrates their competencies in doing their work. CF1 noted,

“They all go through an interview application, they have recognised training qualification that they do need for that specific job. We have five surveyors, seven Contract Managers, we have got a Fleet Manager and Health and Safety Manager who have relevant health and safety qualifications. Our Managing Director, he’s a qualified surveyor and he has health and safety qualification as well”.

In addition, the employees' openness to any changes and new ideas could also contribute to some extent to the effectiveness of the utilisation of the existing knowledge, as open-minded people, often, are more educated people who like to use and exploit their existing knowledge for their own benefit and that of others. However, only two of the building firm respondents have claimed that their employees are in this category. CF1 mentioned,

"I think they [employees] are quite open as I say implementing ISO 14001, there was significant changes to working practices. By introducing new spill cap procedures, that is something new. Recycling within the company, it's something new as well, the employees were embraced. So they are quite well, see the benefit from a personal point of view and they see what the company is trying to do. So they are quite positive about any changes or anything new that is being implemented".

The dimension of employee openness was linked to their youth by CF3, who said, *"Most of the workers are quite young and I think they are quite willing to look at new ideas, new ways of working and new practices"*. On the other hand, other respondents expressed their concern about their employees' attitude towards any changes and new ideas. CF5 reflected,

"I would say on a scale of 1 to 10, about 6 or 7. Because we are quite open but we are very sceptical. We like to stick to what we know, we are always very sceptical for try something new that it will make a difference".

His comments hinted at the desire to know if something would be effective before deciding to adopt new ideas and practices. CF4's comments pointed to a lack of willingness to do things differently,

"Honestly not very [open]. They [employees] take quite a lot to retrain. Generally tradesmen are quite old fashioned. If they learn how to build a house this way when they were 14 or 16, that's the way they think it should still be built 20 years later. They don't tend to want to change because generally change is more difficult. So it takes a wee bit of work to make people change of ideas".

CF4 observations point to the need to educate staff to make them open to retraining, so that they could learn something new to improve their routine of work. Moreover, the level of employees' awareness of environmental issues also contributes to

strengthen their existing knowledge. If they are more aware and concerned about the environment, they tend to use their knowledge, to be better people in terms of protecting the environment. This tends only be evident where employees are working in a firm that has implemented environmental-related initiatives or made efforts in that direction, as mentioned by two of the construction firm respondents. CF2 reflected that employees were more aware and engaged,

“Much more so since we got ISO14001 accreditation and the reason I said that is that everything that we operate has to have environment and risk assessment procedures and protocols carried out. So nowadays, the employees are much more aware of environmental issues related to their work”.

CF1 observed that training had raised awareness of issues, *“They [employees] certainly, they’ve received training on company environmental policy, make them aware of our objectives and targets [related to environmental issues]”*. Another two respondents, however, confidently claimed that their employees do not fall into the environmentally-conscious category of people. CF3 noted,

“[They are] not very aware I would say, probably not very aware. They may have their own personal view of it, of environmental issues, but I suspect that is probably not that many of them that are aware”.

Signs of attempts to enhance awareness were evident in CF4’s comment,

“[They are] not very. Not very aware. Well you know because we are building environmentally-conscious houses, they are more aware of that now than they used to be and I’m trying to make them more, more aware about the importance of sort of, recycling, right, something like that, but it’s quite difficult for tradesmen”.

The above findings have revealed that, in terms of Existing Knowledge Utilisation, the level of employees competencies in the majority of the respondents’ firms can be considered as high, while their attitude towards receiving new ideas as well as their awareness towards the environmental issues can be considered as quite low. This, therefore, is not sufficient to stimulate them to become involved in green innovation or practices. The firms who have capability to utilise and exploit their existing knowledge are likely to become engaged in new practices, such as green innovation, as their organisation’s members are more open to changes. In addition, high levels of

employees' awareness of environmental issues could provide direction to the firms to adopt green innovation.

5.2.2 Absorptive Capacity: Knowledge Building

One of the ways to build organisational knowledge is by offering or sending the employees to attend any types of training related to their work. In terms of developing environmental knowledge and awareness, environmental training could provide new or additional information and knowledge to the participating employees. This therefore, represents the second dimension of a firm's absorptive capacity, namely Knowledge Building (KB). Firms who provide environmental training to their employees have the capability to develop their absorptive capacity. The results of the survey in relation to KB are shown in Table 5.9.

Table 5.9: Summary of the Survey Results on the Relationship between KB and Green Innovation Adoption

Hypotheses	Results
H2a: The presence of a firm's knowledge building effort is positively related to the adoption of green technical innovation	Supported
H2b: The presence of a firm's knowledge building effort is positively related to the adoption of green process innovation	Supported
H2c: The presence of a firm's knowledge building effort is positively related to the adoption of green administrative innovation	Supported

The results of the quantitative study in respect to KB are supported, which revealed that the presence of a firm's knowledge building effort is positively related to the adoption of green innovation. The evidence of the study has strengthen the findings of previous studies. Successful adoption of green practices in a firm requires education and training for its employees. The participation of employees in environmental training could motivate the employees to participate in proactive environmental management (Cook & Seith, 1992), including green innovation. While training and education of employees will contribute to better absorptive capacity of a firm (Kim,

1998), it could facilitates a firm to develop innovative process (Cohen & Levinthal, 1990) and firm's engagement in green practices (Zilahy, 2004; Hart, 1995; Klassen & McLaughlin, 1993).

However, the results from the interviews have shown that the majority of the building firms were not providing environmental training to their employees, as stated by the respondents. For example, CF3 commented, *"I would say we don't have any environmental training"*, and CF4 identified resource constraints as the reason for not providing training to the employees, as he stated, *"As I said, small company, I don't have time to take them through [training]"*. Another respondent, CF5, who indicated his company did not offer environmental training, pointed to a lack of knowledge about sourcing appropriate training as a reason for it, *"We don't know where to start. We have nobody or we don't even know where to go to have somebody do any environmental training here. And we don't even know where to start"*.

Those statements were made by respondents from small companies, which, in general, have limited financial resources to provide environmental training to their employees. Even though they do care about the environment, this kind of training is not really important to them compared with the financial cost versus the possible gain. It is different to larger companies, who have considered the initiative to provide environmental training to employees as a value added to their companies. As they have sufficient financial resource to bring their company forward by providing environmental training to the employees, this initiative has become one of the items on the agenda of their companies. This was demonstrated by the statements made by two of the respondents who are working with large companies. For example, CF1 discussed his company's approach,

"All of our employees have been through environmental training as part of our new environmental policy. It is conducted internally. And to support that we had a range of training for myself as Health and Safety Manager and the senior management. Our environmental consultancy firm, XY Consultants, they delivered additional training to support the environmental management systems".

CF2 also noted how environmental training was being seen as something for all employees,

“The employees have been on, not all of them, but I think we are kind of working towards kind of 100 percent of the staff have been on a range of different courses. Some have been on very specific training, but some of it kind of like broad of overview of environmental training”.

As providing environmental training to employees has its own benefits to the company and the employees themselves, other than increasing the organisational knowledge, one of the respondents, CF1, claimed,

“It’s certainly raised awareness throughout the company, of all environmental issues certainly. I think what we have implemented we can already see the benefits from that which is had closest impact on employees. I am now getting employees challenging people for not using the recycle bins and asking questions or requesting additional recycle bins. I think it’s also raised awareness there in a positive way”.

In terms of the importance of providing such training to the employees, CF2 stated,

“Every staff member has their own sort of personal development plan and training. So you can have on an annual basis, we actually review what training we have, what training might need updated, what training is going to expire and need to be refreshed”.

Those statements reflect how environmental training is emphasised by certain companies especially the large ones as they do not face financial constraints compared to their small counterparts.

Overall, the findings have shown that, as a firm provides environmental training to the employees, it could enrich and improve environmental-related knowledge of the employees, which could influence them to participate in green innovation.

5.2.3 Absorptive Capacity: External Knowledge Acquisition

Relationships with others outside the firms could offer a huge benefit to both parties. Networking or external linkages is one of the main sources of information as well as new knowledge. External Knowledge Acquisition (KA) or knowledge obtained from parties outside of the firm represents the third dimension of a firm’s absorptive capacity. Firms which have gained information or new related knowledge from their

external network could develop their absorptive capacity. The results of the survey in relation to KA are shown in Table 5.10.

Table 5.10: Summary of the Survey Results on the Relationship between KA and Green Innovation Adoption

Hypotheses	Results
H3a: A higher level of a firm's external knowledge acquisition is positively related to the adoption of green technical innovation.	Supported
H3b: A higher level of a firm's external knowledge acquisition is positively related to the adoption of green process innovation.	Not supported
H3c: A higher level of a firm's external knowledge acquisition is positively related to the adoption of green administrative innovation.	Not supported

Table 5.10 shows that the results of the survey in relation to KA are partially supported. It has shown that the level of the firms' external knowledge acquisition is relatively low. The lack of effort of the firms to obtain information and knowledge from external sources discourage the firms to become involved in green practices. As interaction with other industry actors and accessibility of external sources of knowledge could enhance a firm's absorptive capacity, the environmental-related information that has been gained could provide a better perspective regarding to the environment, which could facilitate the decision making process in relation to the adoption of green practices. However, in the case of this study, the results have not been very encouraging.

The interview findings, however, have revealed that all of the building firm respondents have obtained environmental-related or green product information from a number of sources, such as the internet, as stated by CF1, "*Obviously using an internet is a good source [of knowledge]*". Subscriptions to email feeds, newsletters and trade magazines are some of the methods to obtain the latest information on environmental-related issues and products, as evidenced by several respondents. CF2 mentioned, "*We subscribe a lot of kind of email and newsletters and stuff like that*", while CF5 commented specifically, "*Well, sometimes we get trade magazines through, for example we've got on called The House Builder Magazine or something like that*".

Meanwhile CF6 indicated, *“Yeah, we do get flyers that kind of thing and get an email which provides information related to environmental issues and products”*.

However, gathering of most of the environmental-related information is normally as a result of requests from the clients or architects, which resulted in the firms searching for further information from the other sources. Respondent CF3 commented,

“I think that we, probably, if we have been asked by a client or an architect for a specific type of boiler system, for example, and we will look for, you know, what is new in the market, from the internet or through our suppliers. A lot of information comes from our suppliers, what they recommend and how easy it fits and adapts, for our workers to use that”.

Further, CF5 noted,

“It’s normally through the architect. The architect who specifies some new system because it’s more environmental friendly or more economical, and then I am asking for information because when I’m doing a job, I need to know what’s involved. I am asking for information then I need to do some studying on the product, normally just online”.

The findings have surprisingly revealed the important role of architects in the building and construction process, including matters in relation to the adoption of environmentally-friendly practices. While the problem of protecting the environment must be addressed by all parties involved in particular construction projects, architects are arguably at the ‘front line’ in terms of the consequences of their decision (Fuller, de Jong & Mellersh-Lucas (2008). As architects are the main persons who are involved actively, starting from the beginning stage of construction until the completion of construction projects, their work and decisions would directly influence the construction process and the actions of other parties in completing particular construction projects.

Besides that, trade associations in the construction industry have also become one of the sources of information to their members, as claimed by CF2, who was a member of several bodies,

“We also get a lot of information as well from our membership, Federation of Master Builders and NHBC, you know some of the trade bodies that we are members of, they tend to also provide a lot of stuff”.

The other parties who were also identified by the respondents as their sources of information were the architects, consultants, government agencies and suppliers. CF1 mentioned,

“We had a consultancy, XY Consultants, they have been helping us implement our ISO 14001. We have Richard Dunbar, one of the senior consultants, so I have regular contact with Richard, sort of an additional advisor on environmental issues”.

CF2 comments pointed to the way of communication between his company and other parties from outside the firm,

“We communicate with architects and engineers and mechanical consultants, and this all is that kind of flow of information, both ways actually. But we also get information from our supply chain regarding green products in the market, something like that”.

While CF4 also stressed that suppliers of green products is an important source of information, he pointed to the way they approached his company to sell their products, which indirectly provided environmental-related information,

“There’s a certain number of companies that are selling environmentally-sound products. Most of the time they visit our sites in terms of representatives from the companies. You know, if you try to sell me something, part of the selling process would be to explain to me how it’s environmentally-friendly, particularly if you try to sell to an eco-house builder you know”.

Meanwhile, another respondent, CF1, indicated the current environmental information can be obtained from the government agencies, *“We would contact SEPA if we need any sort of relevant sort of up-to-date information.* Another source of information, that is seminars or conferences, were also mentioned by CF4, *“I do go down to the Eco-Build Convention in London every year, it is where to look at products and get up-to-date information”.*

The above findings have shown that all of the building firm respondents have acquired some sort of environmental-related information and new knowledge from various sources outside their firms. This, however, does not necessarily mean that it influences the firms to engage or adopt green-related practices, as happened in the case of most of the respondents.

Further, the third part of the survey findings will be discussed in the next section. Then, the results from the interviews will be elaborated to complement the findings of the quantitative study.

5.5 The Effect of Environmental Requirements on the Relationship between a Firm's Absorptive Capacity and Green Innovation Adoption

Environmental requirements, in terms of pressure from regulators and customers, might have an effect on the relationship between firms' absorptive capacity and green innovation adoption. As one of the objectives of this study is to investigate this matter, the results from the survey will be discussed first, followed by the discussion of the interviews' results with the building firms and the industry experts, in the following sections.

5.5.1 Regulatory Pressure

The involvement of the building firms in certain practices, including green-related ones, could be driven by the regulations or laws. Regulatory pressure, in traditional way, have a significant influence in making firms comply with environmental regulations in order to decrease their environmental impacts (Banerjee, 2001; Walker et al., 2008). Firms that encounter higher levels of environmental pressure from regulators are more encourage to develop their absorptive capacity (Hilton et al., 2000), for instance, by improving their environmental awareness, which then leads to the development of green innovative solutions. The results of the survey on the effect of the regulatory pressure on the relationship between the firms' absorptive capacity and the adoption of green innovation are presented in Table 5.11.

Table 5.11: Summary of the Survey Results on the Moderating Effect of Regulatory Pressure

Hypotheses 4	Results
H4a(i): Environmental pressure from the regulator positively moderates the relationship between a firm's existing knowledge utilisation and the adoption of green technical innovation	All are not supported
H4a(ii): Environmental pressure from the regulator positively moderates the relationship between a firm's existing knowledge utilisation and the adoption of green process innovation	
H4a(iii): Environmental pressure from the regulator positively moderates the relationship between a firm's existing knowledge utilisation and the adoption of green administrative innovation	
H4b(i): Environmental pressure from the regulator positively moderates the relationship between a firm's knowledge building and the adoption of green technical innovation	
H4b(ii): Environmental pressure from the regulator positively moderates the relationship between a firm's knowledge building and the adoption of green process innovation	
H4b(iii): Environmental pressure from the regulator positively moderates the relationship between a firm's knowledge building and the adoption of green administrative innovation	
H4c(i): Environmental pressure from the regulator positively moderates the relationship between a firm's external knowledge acquisition and the adoption of green technical innovation	
H4c(ii): Environmental pressure from the regulator positively moderates the relationship between a firm's external knowledge acquisition and the adoption of green process innovation	
H4c(iii): Environmental pressure from the regulator positively moderates the relationship between a firm's external knowledge acquisition and the adoption of green administrative innovation	

The results of the survey in respect to regulatory pressure, however, are not supported. This situation could directly be clarified by the findings of the interviews. In the context of green innovation adoption, there is no such regulation that could really force the building firms, especially the small ones, to adopt green-related practices. This is what has been revealed by the findings of the interviews. However, most of the building firms which participated in the interviews have agreed that regulation or law, is the main factor that could influence them to become involved in green practices. For example, CF3 stated:

“The only way we gonna do that is, if the government regulations say, no you have to, this is part of it, and if Building Standards say you need to do this, then we need to do it”.

CF2 agreed as he stated, *“I suppose, to some extent the building regulation is a big driver you know”*. CF6 added by stressing the power of law, *“If the Building Standards say, this is a new energy efficiency measure, it means you have to do x, y or z, then we very much have to do it as Building Standards say”*.

Furthermore, most of the industry experts also highlighted the regulatory pressure as the key factor that could influence the building firms to be involved in green practices. One of the industry experts, IE1, gave his firm view, by stating, *“Just government or regulation”*. Agreeing with previous respondents, the other industry experts also had similar views. For example, IE4 mentioned, *“If it’s a law, if it’s yes, that’s the fact of life, the fact that if there’s a legal requirement, there’s the stick element too, I think it has to be done”*. Confident with his observation, IE6 commented, *“Generally the construction industry only moves when legislation drives it”*. Further, IE1 noted, *“Legislation, works every time”*, reflected the voice of IE2, as she stating, *“I think most of it is driven by regulations”*.

Those statements reflect what has been expressed, specifically, by one of the industry experts, in relation to the requirements to meet the minimum standards of the environmental regulations. IE3 mentioned,

“The Building Regulations, minimum standards, but a big driver for companies is actually having to be energy efficient, water efficient, sustainable the buildings, use kind of correct materials, don’t use materials which cause fire and so on and so forth”.

Summing up those statements, IE3 added: *“Regulation tends to make things happen you know”*. However, it is quite an issue, as the majority of the construction firms, in general, are driven heavily by the regulations, but would not go beyond the basic regulatory standards as they need to. This is stressed by IE7, as he stated, *“They [builders] will meet the regulations insofar as they need to. Most of them are not*

trying to do much beyond that". The statement is agreed by one of the construction firms, as CF4 commented,

"There's no point building to the super high standard if no one is gonna buy it or occupy it or doesn't understand it, so in my opinion everyone should be meeting the minimum standards".

In the case of this study, the impact of regulation on the construction firms can be considered as low, as the building firms only try to fulfil the minimum requirements of the particular regulations while doing their construction works. An industry expert, IE7 mentioned,

"The majority are simply trying to stay with in the regulations as they improve every four or five years. So partly that's because the regulations have changed so quickly, partly because there is no perceived value in beating the regulations".

Strengthening the statement, IE3 voiced, *"I will suggest it's not that many that went beyond the actual minimum standards"*. IE7's observations point to the ignorance of the environmental regulations, especially by small firms. He commented,

"They are not particularly concerned, the environment is not a big issue for them and has not been traditionally. For themselves, there are very few rules they can't either get round or ignore and so on. So there is a challenge there, yes, particularly for the small companies".

On the other hand, the perspective from the industry expert was reflected by a building firm's respondent, CF5 who was not aware of any regulation related to environmental-related practices by stating: *"Well, if there was any legislation or regulation in that, you know we need to stick to it but there's none. I'm not aware of any regulation or legislation"*. The same goes for another small builders, CF4 as he mentioned, *"There's no penalty or anything like that [related to environmental regulation]"*.

This finding is surprising, and this type of attitude among small firms is very worrying. Even though action towards compliance with regulation is dependent upon motivation and the fear of being punished, it also depends on capability; skills, money and knowledge (Petts, Herd, Gerrard & Horne (1999). In the case of some of the small firms in this study, they are lacking knowledge and awareness of the importance of

protecting the environment, which contributes to ignorance regarding the existence of environmental regulations with which they should comply. At the same time, particular environmental regulations have been seen to be weak because of the lack of regulatory support (Baylis, Connel & Flynn, 1998). Furthermore, as they mostly suffered from limited resources and financial capability, their particular concern is more to do with making a profit than the importance of environmental protection and related regulations.

However, the regulations, actually, are there. Some of the examples are, duty of care and waste disposal regulations which were introduced to facilitate the construction firms in the UK to dispose of their waste in an appropriate way. The government introduces regulations to be followed in almost every aspect of people's life, including environmental-related regulations within the industry. This is explained by IE3, *"You know so there's a number of, there's lots of building regulations there that lead to building being safe, energy efficient and sustainable"*.

The above statement, is to some extent, related to the building firms' knowledge. Small firms, as they are working on small scale projects, they do not think that their small piece of work will be effected by or could be related to the regulations. Therefore, they would not bother about any regulation, not to mention, undemanding regulations, which fall into voluntary category of regulations¹³.

Overall, those statements from the building firm representatives and industry experts have strengthened the findings of previous studies (e.g. Delmas, 2002; Majumdar & Marcus, 2001; Revell & Blackburn, 2007) that regulatory pressure could play a very strong role in influencing construction firms to adopt green-related practices. Once construction firms aware of the regulations which need to be complied with, they will do as they are asked to. However, to date, based on the survey's and interviews' findings, there is still no regulation that is stringent enough to do so, especially when the existing ones do not directly affect particular firms.

¹³ *Voluntary regulation* is a mechanism that can be used within a regulatory framework as an alternative to statutory regulation, to achieve a particular outcome through a change in behaviour (Scottish Government, 2016).

5.5.2 Customer Pressure

Pressure from customers, in the same vein, also has a great influence in making construction firms become involved in green-related practices (e.g. González-Benito & González-Benito, 2006; Delmas & Toffel, 2004; Henriques & Sadorsky, 1999). As construction firms are doing work for clients, they should fulfill the clients' requirement, including any request related to environmentally-friendly matters. Table 5.12 presented the results of the survey in relation to the effect of customer pressure on the relationship between firm's absorptive capacity and green innovation adoption.

Table 5.12: Summary of the Survey Results on the Moderating Effect of Customer Pressure

Hypotheses 5	Results
H5a(i): Environmental pressure from the customer positively moderates the relationship between a firm's existing knowledge utilisation and the adoption of green technical innovation	All are not supported
H5a(ii): Environmental pressure from the customer positively moderates the relationship between a firm's existing knowledge utilisation and the adoption of green process innovation	
H5a(iii): Environmental pressure from the customer positively moderates the relationship between a firm's existing knowledge utilisation and the adoption of green administrative innovation	
H5b(i): Environmental pressure from the customer positively moderates the relationship between a firm's knowledge building and the adoption of green technical innovation	
H5b(ii): Environmental pressure from the customer positively moderates the relationship between a firm's knowledge building and the adoption of green process innovation	
H5b(iii): Environmental pressure from the customer positively moderates the relationship between a firm's knowledge building and the adoption of green administrative innovation	
H5c(i): Environmental pressure from the customer positively moderates the relationship between a firm's external knowledge acquisition and the adoption of green technical innovation	
H5c(ii): Environmental pressure from the customer positively moderates the relationship between a firm's external knowledge acquisition and the adoption of green process innovation	
H5c(iii): Environmental pressure from the customer positively moderates the relationship between a firm's external knowledge acquisition and the adoption of green administrative innovation	

The results of the survey in relation to customer pressure shown that the hypotheses are not supported. However, it has been revealed by the interview findings, besides regulations, the building firm representatives also highlighted the influence of customers on their engagement in green practices. For example, CF2 observed that a driver for his firm's adoption decision was that, *"Our clients. They expect us to"*. CF3 pointed their willingness to adopt green practices, only if there is a request from their customer. He noted, *"We are driven by demand, if our clients demand it and if the architects that we work for demand it then we will use it [green product or practice] because otherwise we won't"*.

Some of the industry experts have also mentioned about the influence of customers in facilitating the building firms to adopt green practices. IE7's observations point to the necessity of the building firms to identify their customer needs, as it would direct their action towards green initiatives. He commented,

"Personally, I think they would need to see that their customer wants it for them to change [become greener], so you need pressure from both sides basically, one on the regulatory side and one from the market, and if you saw that then you might see some changes".

IE4's response reflected the influence of clients in shaping the construction output, noting, *"There's certainly their clients who want it, their clients and potential clients and that's often demand led"*.

Public sector or commercial projects, basically, are customer-driven projects, which certainly, need to be accomplished according to customer requirements. However, when it comes to environmental-related aspects, only customers who are willing to pay extra would go for it. This is expressed by one of the building firm respondents, CF3, as she stated,

"The better environmental choice involved extra cost, I guess to the client, so that's not always could be their first choice. I guess there's gonna be a very small proportion of people that are willing to get that a go".

Additionally, an industry expert, IE2, had given her view relating to this by emphasising the factor of clients' determination to proceed with their environmental choices. She claimed,

"The incorporation of green technology does still add capital cost to the services, so the client has got to be willing and has got to have the ability to pay that extra premium for it, and he or she has got to have the desire to do that".

Even though cost is a major factor that influences the client preferences, CF3 observed that the customers' desire to choose environmentally-friendly aspects of their choices is paralleled with the increasing level of awareness of better environmental choices, of certain people, *"I think it's increasing, I think we probably see more people looking for more, better environmental choices"*.

However, most of the customers, in general, are not looking at environmental-friendly aspects of a building, as investing in buildings or properties is very costly. They, generally, would rather focus on other factors such as location of the property or the number of rooms it has. This has been mentioned by one of the industry experts, IE3, as he stated,

"When buying a house, it's not a question that my children would say to the housebuilder, the energy efficient in this building, what sustainability has it got. They are more incline to say where's the way to school, what's my council tax, what size of kitchen does it have, how many bathroom does it have, they will ask the whole range of questions before they would get to the energy efficiency".

In such a case, it is, to some extent, related to the level of awareness of the environmental-related issues, which results in low demand for green features. This aspect was expressed by IE3, as he mentioned, *"I guess what stops people [ask for green features] is they don't see the value, so they don't buy, so why waste the money"*. Voicing a similar sentiment, IE5 expressed his view by stating,

"I think probably the single biggest thing is for the consumer to appreciate that, it was one of those decisions or issues that mattered to them. New building is source of demand and I think what's not there at the moment is that the green initiative are not valued".

As the findings of the survey were not showing the effect of customer pressure on the relationship between firm's absorptive capacity and green innovation adoption, the interviews' findings have shown that, customer pressure towards green initiatives could be considered as low, at the moment. This, therefore, could not encourage the construction firms to develop their absorptive capacity, in terms of increasing and improving their environmental-related knowledge, as there is no pressure factor from customers, which leads to low levels of engagement in green practices.

5.6 Concluding Remarks

In this chapter, the findings of the survey were explored through the interviews to deepen understanding of the quantitative results. This study has attempted to examine the level of green innovation adoption among Scottish building firms. In addition, the researcher has made an effort to investigate the relationship between a firm's absorptive capacity and green innovation adoption as well as to analyse the moderating effect of environmental requirements on the particular relationship. A firm's absorptive capacity was measured by looking at three dimensions, namely Existing Knowledge Utilisation (KU), Knowledge Building (KB) and External Knowledge Acquisition (KA). Specifically, the findings of the survey have shown the level of adoption of green innovation among Scottish building firms is relatively low. Meanwhile the hypotheses in relation to KU and KA are partially supported, the hypotheses with regard to KB is strongly supported. In sum, the level of firms' absorptive capacity is not sufficient to influence the building firms to become engaged in green practices as they are facing a number of limitations such as cost, effort, and culture, as well as some more other factors which also have been discussed in this chapter.

The chapter has also discussed about the effect of the moderating factors. As legislation could be seen as the main driver that could encourage the building firms to become engaged in green practices, its enforcement can be considered as not stringent enough. The customer demand for green features, in the same vein, could be one of the great drivers of building firms' engagement in green practices. However,

the cost factor as well as the low level of awareness about the advantages of green practices, have made the customers prefer conventional over environmental choices. As a result, both factors, the regulatory and customer pressure, do not have the moderating effect on the relationship between firms' absorptive capacity and green innovation adoption since the low pressure of both factors could not encourage the firms to develop and increase their absorptive capacity, and involvement in green practices.

The next chapter will discuss the conclusion of the research work by first discussing the contribution and implication from the findings, to theory, policy and practice. Afterward, the limitation of the study will be discussed along with avenues for future research.

CHAPTER SIX: CONCLUSIONS

6.0 Introduction

This final chapter draws together the overall findings of this research. It relates these findings with those of existing studies. Also, a summary of the study and conclusions drawn from the empirical investigations are presented. In order to do so, it is divided into a number of sections. First, a summary of the study is presented, followed by a discussion of the implications of the study for theory, policy and practice. Finally, the chapter highlights the various limitations of the research and presents suggestions regarding possible directions for future research.

6.1 Summary of the Research Findings

This section summarises the main findings of the research, with respect to each of the research objectives.

6.1.1 Reassertion of Research Objectives

With the trends of green economy and entrepreneurship where companies aimed at reducing environmental problems resulted from their business activities, environmental awareness has become one of the great opportunities for firm growth. Firms have to seize the opportunity to protect the environment by, for instance, engaging in green practices or innovation even though they are operating within a traditional industry such as the construction industry. As many of the construction activities contribute to some extent to environmental impacts, construction firms, as a whole, have to move towards greener activities and prevent the negative effects of their activities from becoming a threat instead. Pursuing green activities can be considered as a form of innovation since it is concerned with new practices that require some extent of efforts towards environmental protection and reducing impact on the environment. Nevertheless, the construction industry has been labelled by previous researchers (e.g. Reichstein et al., 2005), as not really interested in these types of innovation as well as having little interest in green issues. Hence, this research aimed

to investigate the level of green innovation adoption among firms in the building sector in Scotland (the first research objective). Scotland is of particular interest as its construction industry has been actively making a contribution towards the country's Low Carbon Strategy. The industry has worked collaboratively with numerous parties including the government, representative organisations, various federations, as well as universities to educate its construction participants to be aware of the benefits of sustainable construction (Construction Scotland, 2012).

Additionally, a particular firm's capability, called absorptive capacity, has been identified as one of the key factors that contributes to the adoption of green innovation (Davids & Tai, 2009; Nieto & Quevedo, 2005; Lenox & King, 2004). Absorptive capacity is a concept that reflects the capability to utilise and develop internal knowledge as well as capability to acquire external knowledge which could enable firms to become engaged in new practices or innovation. In other words, both internal knowledge building and external knowledge acquisition which form the absorptive capacity concept could be seen as playing important roles in influencing a firm's intention to adopt green innovation practices. As there is relatively little empirical evidence on the association between absorptive capacity and green innovation adoption, this study has attempted to investigate the role of absorptive capacity in influencing the adoption of green innovation, with the construction industry as its context (the second research objective).

Previous studies have shown that environmental requirements, in terms of regulatory and customer pressure, have affected the adoption of green innovation practices (Lee, 2008; Chrismann, 2004; Wong & Fryxell, 2004). However, conflicting results from previous studies on the relationship between both types of pressure and green innovation called for new evidence and insight to be obtained. Thus, this study argued that regulatory and customer pressure might play an important role in driving the adoption of green innovation practices, but in the form of moderating effects. This brought the researcher's attention to examine the effect of environmental requirements on the relationship between the firm's absorptive capacity and the adoption of green innovation (the third research objective). All those three research objectives were addressed by using a mixed methods approach; a survey and a number of interviews

with representatives of firms in the construction industry and a group of other key stakeholders from the sector, as reported in Chapter Three. The utilisation of a mixed methods approach was highly valuable to help achieve the overall aim of the research.

6.1.2 The Level of Green Innovation Adoption by Scottish Building Firms

In Scotland, the construction industry is vitally important to the economy, employing around 170,000 people; which is about 10% of all Scottish jobs (Construction Scotland, 2012). The industry is dominated by micro businesses, which account for around 90% of the sector (Office of National Statistics, 2015). Self-employment is significant, accounting for around 39% of the workforce (Office of National Statistics, 2015). The wider workforce associated with the activities of the industry is also diverse; from architects and civil engineers to painters and decorators, the wood/carpentry trades and electrical trades. Those working as builders are part of the workforce who are directly involved in a major part of or the entire process of construction works. Many of the firms for which they work fall into small-and medium-sized firms' category.

This study has investigated the level of green innovation adoption by the building firms in Scotland, by looking at two firm-specific factors; firm size and firm age. These two factors are often used in most studies of adoption behaviour (Karshenas & Stoneman, 1995). Large firms have been argued as having advantages in terms of resources and management structure (Lepoutre & Heene, 2006), while firms with a long period of time in business operation can be considered as having accumulated experience (Giunta & Trivieri, 2007), which could influence their adoption decision (Baptista, 2000).

The evidence from the quantitative phase of this study showed that building firms had engaged at a relatively basic level in the adoption of green practices, particularly in green technical and green process practices. Specifically, by looking at the firm size, in terms of green technical practices, the large firms have shown a higher percentage of adoption compared to small and medium-sized firms. They have been focusing on

monitoring the emission of hazardous substances or waste during construction activities, adopting the technology/ processes of pollution prevention, technologies associated with energy conservation, and technologies to help control noise. In terms of green construction processes, firms in both large and small size categories have been found to focus on conservation of the natural environment, the efficient utilisation of energy, and the consumption of locally-sourced materials for construction. Those are the basic practices which have been suggested by Qi et al. (2010) to be promoted through managing the construction activities. These building firms have shown evidence of their effort towards minimising the environmental impact related to their operations. However, green administrative practices were adopted by few firms across all category size of companies. Out of five practices, environmental documentation was the only practice which was adopted by large companies. Overall, the results have shown that the adoption of green practices is dominated by large firms. As mentioned by Kelley and Helper (1999), a propensity of a firm to adopt a new practice is a function of organisational capabilities related to size. Large firms who have greater financial availability are more able to use green-related technology, undertake environmentally-friendly construction process, and spend more on using green administrative practices, when required.

In terms of firm age, the findings of the survey revealed that older firms (developing and established firms) have shown a higher percentage of adoption of green technical practices compared to their new counterparts. The established firms, who have demonstrated the highest level of adoption of green technical practices, have been focusing more on monitoring emission of hazardous substance and waste, and adopted technology of pollution prevention, while the developing firms have been adopted the technology associated with energy conservation and technology of pollution prevention. On the other hand, when looking at the adoption of green processes, conservation of natural environment has shown the highest percentage of adoption which mostly adopted by older firms. In terms of green administrative practices, older firms have shown a higher percentage of having environmental documentation compared to younger firms. Overall, older firms seem to adopt more green practices

than younger firms, particularly all the three types of practices; green technical, green process and green administrative.

The use of qualitative method in the second stage of data collection has provided deeper understanding of the quantitative results. The statements given by the management in the building firms themselves, as well as the industry experts, have provided additional evidence that the level of green innovation adoption among firms in the Scottish construction sector is relatively low. This is because the firms have focused more on achieving financial goals than pursuing the environmental agenda, which can directly and indirectly involve greater cost. The cost issue is really a matter for all size categories of firm within the construction industry, not just small firms which are often more resource constrained, particularly when it comes to finance.

6.1.3 The Role of Absorptive Capacity in Influencing the Adoption of Green Innovation

This study has argued that the intention to become involved in green innovation practices will depend on the organisational capabilities to acquire, assimilate and apply related knowledge. Absorptive capacity plays an important role in the adoption of green innovation (Lin & Ho, 2008; Bernauer et al., 2006). Moreover, green innovation requires new knowledge to be assimilated and transformed throughout the organisation (Hordern et al., 2008), as well as proper utilisation of existing knowledge, as the requirements for its successful implementation. In order to investigate the relationship between firm's absorptive capacity and the adoption of green innovation, both a survey and a number of interviews with a variety of actors representing different stakeholders involved with the construction sector were carried out.

For the first phase of data collection, the hypotheses model are partially supported, which, to some extent, could strengthen the evidence from the previous studies (Davids & Tai, 2009; Lenox & King, 2004). Even although those studies have shown the proof of influential factor of absorptive capacity on the adoption of green practices, they have been undertaken within the manufacturing sector, which is different from

the construction sector in terms of the nature of its business processes. While manufacturing involved ongoing and repetitive processes of producing its outputs, construction involved the implementation of projects which are temporary and creating unique outputs (Pinto et al., 2016). The distinction demonstrated the slight difference in the results of study between both sectors, as some part of the hypotheses are not supported.

In particular, the presence of a firm's knowledge building in terms of providing environmental training to the employees, contributes to the adoption of all three types of green practices (Hypothesis 2a, 2b and 2c). This result is aligned with previous research findings conducted by Zilahy (2004), Hart (1995), and Klassen and McLaughlin (1993). It has also strengthened the statement made by Cohen and Levinthal (1990) that the acquisition of relevant knowledge through learning or training could facilitate a firm to develop innovative processes or products, by highlighting how the forms of innovation introduced/adopted extend to those associated with green activities. The evidence points to this as having been done, particularly, by large firms, as costs related to providing training for their employees is not such a big issue as it is for smaller organisations.

On the other hand, the evidence from the interviews has shown that building firms generally showed a relatively low level of adoption of green practices despite the fact they have a fairly high level of absorptive capacity. Even in firms with employees who have collectively been equipped with the skills and knowledge associated with environmental-related issues and information, it is still not enough to drive green practices forward. This finding represents the reality of the work style and culture of the majority of construction firms. New knowledge and information does not seem to be able to take over from the basic knowledge and traditional routines that have been embedded in their work practice. Thus, the finding may be of importance in pointing to the need to focus also on the barriers standing in the way of the adoption of green practices within the construction industry.

6.1.4 The Effect of Environmental Requirements on the Relationship between the Firms' Absorptive Capacity and the Adoption of Green Innovation

Most of the firms which have been involved proactively towards protecting the environment usually experience some extent of pressure to do so. Despite various driving factors, environmental requirements in terms of regulatory and customer pressure have been argued to play an important role in driving firms to become involved in environmental activities (Lee, 2008; Chrismann, 2004; Wong & Fryxell, 2004). However, since previous studies have shown conflicting results on the relationship between both type of pressure and environmental innovation, this study assessed the moderating effect of regulatory and customer pressure on the relationship between absorptive capacity and the adoption of green innovation. A survey was conducted, at first, to fulfil the aim of this third research objective.

When investigating at the moderating effect of regulatory pressure on the relationship between firms' absorptive capacity and green innovation adoption, the results of the survey do not support the hypothesised model. Specifically, there is no moderating effect of regulatory pressure on the three dimensions of absorptive capacity and the three types of green practices. This evidence has then been complemented by the findings from a number of interviews with management representatives of six building firms and seven industry experts, in order to seek a deeper understanding of the factors at play, by asking further questions in order to check and compare evidence.

The findings from the interviews have highlighted the very great influence of regulators in encouraging those in the building sector to be more involved in green practices. Both the representatives of the building firms and industry experts agreed on this matter. However, the existing regulations are not stringent enough to drive building firms to adopt green practices, as most of them would not go beyond the basic regulatory standards to which they are required to adhere. The interview findings, therefore, echo the results of the survey.

In terms of the moderating effect of customer pressure on the relationship between firms' absorptive capacity and green innovation adoption, overall, the results do not

support the hypothesised model. Given that the theoretical model is also not supported in general, the interviews provided an opportunity to talk further with those involved in the sector to check the results of the survey. In general, the participants from the building firms agreed that they are driven by customer demand in producing a particular construction output. However, when it comes to environmental-related aspects, only customers who are willing to pay extra would ask for it. The evidence from the industry experts agreed with this, and they also highlighted the low level of environmental awareness among the customer. Thus, the evidence from the interviews is aligned with the quantitative results.

In the light of these findings, prior theories are re-visited. The contributions and implications of the study, along with the constraints faced by the researcher in conducting the study are discussed in the following section.

6.2 Contributions of the Study

This study makes a contribution in several ways; a contribution to theory, policy and practice. In terms of theoretical contributions, the study contributes to existing literature on environmental innovation with regards to the research context and the specific focus of the adoption of green innovation. Numerous studies have tried to gain a deep understanding of environmental innovation, with much of this work predominantly focusing on the manufacturing industry (Etzion, 2007; Henriques & Sadosky, 2007; Chang, 2011; Dutz & Sharma, 2012). Increasing focus and attention has been placed on the logistic industry as well (Lin & Ho, 2008; Chiou et al. 2011; Lin & Ho, 2011), somewhat leaving behind the construction industry which some researchers have assumed lacks innovation (Barlow, 2000; Blayse & Manley, 2004). The current study has gained insights into how the management of firms in the construction industry cultivate and implement innovation activities within their organisations. Building firms, relatively, have increasingly engaged, but rather slowly, in new practices or green-related innovation activities. They have focused more on basic and low-cost activities such as conserving the environment of the surrounding

area of the construction site, using energy efficiently as well as recycling and reusing construction materials. The exploration for reasons behind this revealed that, as the majority of the building firms are small, the engagement in innovation activities is mostly subject to a firm's economic circumstance. Limited resources, especially, in terms of financial availability, deterred small firms from engaging in more intricate green practices, (e.g. using machines or technology), which involved large amounts of money. The findings, to some extent, have strengthened the assumption made by previous studies in relation to the level of innovation within the construction industry, yet, have shown evidence of a small amount of improvement. In addition, this study differs from previous studies which focused more on manufacturing and logistic industries, and have mostly shown the significantly high level of engagement in innovation activities (Henriques & Sadorsky, 2007; Chiou et al. 2011; Lin & Ho, 2011).

On the other hand, as project-based organisations, their operations differ from typical business firms. In general, business processes are ongoing and repetitive, whereas project processes have a tendency to be temporary and unique. Firms usually develop routines in their business activities. These routines can stimulate innovation, providing opportunities for standardisation and sustained process improvements. By contrast, project processes usually present non-routine features that do not lend themselves easily to systematic repetition. This can limit opportunities for process improvement, standardisation and economies of scale (Gann & Salter, 2000). The findings of this study have strengthened those claims whilst understanding this interesting nature of the industry.

Furthermore, the study contributes to the clarification on the relationship between firm's absorptive capacity and green innovation adoption, which is underexplored by previous studies, within the construction industry. More specifically, this study contributes to knowledge-based and diffusion of innovation theory in the context characterised by construction firms. Within the advancement of understanding of the relationship between a firm's absorptive capacity and green innovation adoption, there is a key element that represents an important empirical contribution in this study. The

evidence of this study has shown that, within the construction industry, there is a very low interaction between a firm's absorptive capacity and environmental requirements in encouraging the adoption of green innovation. The result is in contrast to the results of others (Nieto & Quevedo, 2005; Davids & Tai, 2009), showing that the existence of firms' absorptive capacity is not necessarily a contributor to the firm's adoption of green innovation practices. Part of the reason is that, green innovation represents a relatively new territory and area for consideration for organisations within the construction sector, hence, it requires firms' willingness to be prepared to adopt the new ideas and practices. Moreover, there are a number of barriers which have to be faced by construction firms such as cost, culture around current practices/approaches and effort, in order to become engaged in green practices.

This study also makes a methodological contribution in that it has adopted the mixed method approach for undertaking research in the construction industry, a sector which (Dainty, Moore, & Murray, 2006) claimed has relied heavily on quantitative methods. This study, therefore, provides evidence and support for the use of mixed method approach in construction research. Its usage has offered benefits where the quantitative findings have revealed the general patterns of evidence/behavior and while the results of the qualitative analysis have been used in attempt to explain why these patterns occur.

The evidence of this study also provides valuable and strategic insight into firms' corporate strategy. Construction firms, especially, could increase their awareness regarding the importance of protecting the natural environment from the negative effects of their construction activities. In addition, for organisations who are in search of innovation and effort towards firm growth, understanding of the absorptive capacity concept and how to make use of it more effectively could help them to become engaged in innovation activities, particularly in green innovation. This study could also raise their attention on the requirements or demand from regulators and customers nowadays, in regards to green practices, which could assist them in preparing the future plan of their business.

Likewise, this study also offers something to be thought about by architects. As one of the categories of industry experts and professionals within the construction industry, who are working closely with those in construction firms, they are in a potentially useful position to have a very strong influence in encouraging building firms to become involved in green practices. Yet, the architects, if necessary, should thinking of giving some opportunities to the building firms to come forward with green ideas and work together with them as early as possible in the life of a project. This might help to increase the frequency with which building firms become involved in the use of green practices, while they also could contribute to the realisation of particular projects by offering their ideas around green innovation.

The evidence of this study also provides useful insight into policy strategy. The regulators who have control over certain business activities within the industry, are in great position to encourage construction firms to adopt green practices. As the findings of this study have shown that most of the construction firms preferred to do the minimum in regards to certain regulations, particularly environmental regulations, the regulatory bodies might need to re-consider the issue of enforcement of particular regulations. As for other participants in the building industry, this study offers valuable information on the driving factor of firms' engagement in green practices, particularly, a firm's absorptive capacity. A great understanding on the role of absorptive capacity of a firm and its link with firms' adoption of green practices could influence the industry participants, together, to contribute to the development of a firm's absorptive capacity. The interaction and cooperation among all participants within the industry, therefore, could assist in fulfilling the industry's sustainability agenda.

This study, at the same time, has brought the academics closer to understanding of firms' behaviours regarding their intention to adopt green practices. Particularly, the study has provided evidence on why some firms are more engaged in green practices than others. One of the reasons is closely related to the firms' financial availability, which is really matters, as majority of the construction firms are small. In addition, academics could also gain deeper understanding on the influence of absorptive capacity on green innovation adoption, yet the need to reconsider ideas about the real

benefits of developing and utilising a firm's absorptive capacity to become engaged in green practices.

6.3 Implication of the Study

It is clear from the research findings reported in the previous chapter that Scottish building firms have shown a relatively slow movement towards green initiatives. They are keeping on thinking as to how to survive in the competitive marketplace by focusing more on the economic aspects. With the increasing concern over the environmental impacts resulting from construction activities, those in the building sector need to place more emphasis on the environmental aspects as well, in order to outperform their counterparts. To do so, they have to understand what out-performance means to their customers, for instance, providing an outstanding service, by considering environmental aspects. When they have such an understanding, there is a requirement for them to determine how best to convey such performance, and continually to keep up and enhance that performance. To be specific, the adoption of green innovation or practices can lead to improvement in firm performance (Chiou, Chan, Lettice & Chung., 2011; Chang, 2011; Chen, 2008). Therefore, an understanding of the potential impact of green innovation adoption in building firms is important if its benefits are to be communicated to organisations which might benefit from adopting innovations themselves.

In addition, the evidence from this study revealed that the building firms did not fully utilise and bring forward into practice their internal and external knowledge related to the environment. This was due to most of them having relatively limited knowledge and related information, which in effect, was insufficient so it could not really drive them to become engaged in green practices. Therefore, more effort towards increasing awareness and knowledge regarding environmental issues could be brought to bear by the construction industry experts. The information, previously, might not have reached those in the construction sector, or had little or no effect on them. High profile campaigns on the necessity of taking care of the natural environment, in parallel with

the readiness of the industry experts and professionals to provide assistance to those in building firms, may be very valuable (e.g. the Considerate Constructors Scheme).

Besides, there is also an urgent need to educate society on how they as customers and users of construction outputs can contribute to environmental protection or sustainability. The demand of customers determines the development of environmental-friendly construction outputs, which demonstrates the builders' adoption of green practices while implementing construction activities. Environmental-related education could be started at every level of society. Whilst educating students is an important part of the picture, this could be coordinated as a feature of their personal development plans so as to ensure that upon leaving school, those who are seeking to move into positions of leadership within the construction industry, in the longer term, have the scholarly attributes to make them well-placed to develop into future leaders within the industry, as well as the responsible actors to drive industry towards a sustainable future.

As the role of trade associations within the construction industry is not really appreciated by some of the construction firms, they have to raise and demonstrate their main role as representative of the construction firms, which could really protect the firms' interest, as well as help them grow and improve their businesses. The trade associations, on the other hand, should have demonstrated the value of being a member of the associations by providing continuous support in terms of advice and services to their members. This includes disseminating information and running campaigns to promote green awareness, which directly educate the construction firms on the importance of being environmentally responsible.

On the other hand, regulators should be aware of the possibility of ignoring procedural compliance on the part for building firms. As the evidence of the study suggests that some of the building firms are not aware of any regulations, while some of them were thinking that their business activities are not affected by certain regulations, it shows, to some extent, their ignorance of existing regulations. More stringent regulatory targets should be imposed as it would be a more direct way of requiring the building

firms to be greener. It might be tempting to just say, ‘apply pressure or do not regulate’, but the enforcement of particular regulations might be useful for firms to get prepared for future regulatory requirements.

Also, greater attention should be paid to the top management or decision makers within the firms. There is a pressing need to educate those who are in that position, regarding the importance of environmental protection, as they are involved in making decision including on their intention to adopt green practices. Targeting these individuals and instilling green-related kinds of values might motivate them to make decisions based on the needs of the wider community and environment and not solely on the needs of the firm. This top down approach would also be used to develop firms’ absorptive capacity by, for instance, hiring staff who have basic knowledge on environmental issues, providing environmental training for each staff member, and encouraging staff to expand knowledge in regards to environmental issues.

The above statements have reflected the necessity of knowledge, both within or from outside the firm, that is part of a firm’s absorptive capacity. The existing and newly acquired environmental-related knowledge, if properly utilised, could influence firms to adopt green practices which reduce their impact on the environment and, hence, contribute to enhanced levels of environmental protection.

6.4 Limitation of the Study

The results of the study should be viewed in light of the constraints faced by me. The study suffered from several methodological limitations. First, the research was non-experimental in nature which makes cause-and-effect relationships difficult to establish. Moreover, the use of a cross-sectional survey methodology for the first phase of the study did not allow for the examination of trends over time. Hence, the results should be interpreted with caution as they present a snapshot rather than longitudinal perspective.

Second, the total number of responses for the survey was relatively small given the number of variables in the research model. Even although several approaches were used to increase the response rate, the difficulty of gaining cooperation from potential respondents imposed limits on the number of responses. Indeed, the most difficult part of this study was gaining input and feedback from the respondents. Likely, this will be a significant barrier that organisational researchers will continue to face. In addition, as a series of interviews were conducted following to the survey, the measures of a firm's capabilities and practices were based on the perception of a single informant from each firm. The usage of perceptual measures was due to the fact that relevant objective measures on a firm's activities and processes were not publicly available. In addition, the usage of single informant could increase the impact of potential inaccurate recall, hindsight bias and subconscious attempts to maintain self-esteem (Kumar, Stern & Anderson, 1993). Although I have took into consideration the informant's knowledge about their firm's overall activities as well as confirmed the job title of the informants to ensure this would not lead to systematic differences, future researchers should consider gaining further information by interviewing multiple participants from each firm. The more the participants, the richer and more useful the information could be which is gained on issues being investigated.

Another limitation is that, the geographical extent of the study was limited to Scotland. However, the researcher considered the findings relevant at that time to the wider construction industry in the developed world. The adoption of green practice within the construction industry, to some extent, is increasing but facing some limitations especially amongst small firms, which dominate in the sector.

Further, this study did not collect data directly from the customers of construction firms, even although customers are one of the key variables in the research model, due to the fact that it is quite difficult to identify and classify them. Hence, considerable effort was made to get valuable views from participating construction firms as well as some industry experts regarding the customers' requirements within the construction industry in general. However, the real voice of customer, if it could be heard, might be able to provide stronger evidence on issues being investigated. Whilst the customers

are the most important actor in a construction project where the construction outputs are prepared according to their requirements, it is important to develop a better understanding of their attitudes and needs.

In light of those limitations, some suggestions for future research are discussed in the final section.

6.5 Suggestions for Future Research

This study provides several potential paths for interested researchers to pursue further research. Despite the growing attention being paid to green or environmental issues in the innovation literature, there is still a need for more evidence on the extent to which organisational knowledge capabilities drive firms' intentions to adopt green practices. Firms' capability to acquire, assimilate and apply related knowledge, really matters, and cannot be taken for granted.

What remains to be investigated further are ways in which green practices can be initiated within the construction industry. A more detailed investigation of the participants would be required to draw further information about them, not to mention, details about their past experience. It could be very interesting to ask them to reflect on their past experience as this might inform their behaviour, enhancing comprehension of their present actions and those in the future. Re-interviewing the participants of the present study in the future may uncover trends in adoption over time as well as examining how influences change, expanding on the longitudinal nature of the research. On the other hand, interviewing multiple participants from the same firm would also be a good way of obtaining rich and useful information on issues being investigated. Different people with different expertise and experience might uncover different angles of particular issues, and hence contribute to a better evidence base for the research.

In addition, there is a massive opportunity to investigate the influencing role of the construction industry professionals in the engagement of building firms in green

activities. In the UK, in addition to the different types of stakeholder represented in this study, there are other environmental professionals (e.g. environmental engineers and waste managers), who deal with green issues, who could contribute their knowledge within the scope of this research. Drawing on those with wider perspectives, therefore, could benefit future researchers.

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Appendix 1
Invitation Letter to Participate in the Survey



THE UNIVERSITY
of **EDINBURGH**

University of Edinburgh Business School
29 Buccleuch Place
Edinburgh
EH8 9J

Dear Sir/Madam,

A survey of green innovation adoption among construction firms

I would like to invite your participation in this research study which seeks to deepen understanding of construction firms' involvement in green innovation, and the role that existing and new knowledge plays in determining its adoption.

It is expected that the results will provide information on the range of green practices which firms have adopted and highlight key sources of knowledge and data which they have used when deciding what approaches to adopt. As someone who is operating a business within the construction industry I am hoping that you will provide information via this survey on the current activities of your firm, thereby helping me to develop a detailed view of green innovation adoption within the sector.

Your input to the research is very important and I would, therefore, be most grateful if you would complete the questionnaire via the link which is provided below. The questionnaire will take around 15 to 20 minutes to complete. Participation is completely voluntary and you and your business will not be identified in the study, as analysis will focus on broader trends and levels in green innovation adoption within the industry. You are assured that the information obtained from this survey will be kept strictly **CONFIDENTIAL** and will be used for research purposes only. There are no identified risks from participating in this research.

If you would like to receive a copy of a brief report detailing the results of this research I will be happy to provide it upon request.

This survey is being conducted by me, Mrs Rushanim Hashim, a postgraduate student from the University of Edinburgh Business School, under the supervision of Professor Sarah Cooper (University of Edinburgh). If you require any further information or clarification, I would be pleased to answer your questions and I have provided my contact details below.

I appreciate that the questionnaire requires input of your valuable time but your experiences and industry perspective are vital if the research is to achieve its aim. It is my hope, therefore, that you will assist me in this work by completing the questionnaire which is accessed by clicking on the following link:

<https://www.survey.ed.ac.uk/greeninnovation>

(Please note if you have trouble accessing the survey through this link, you can copy and paste the link directly into the address bar of your Web browser).

Thanking you in anticipation.

Yours faithfully,

Rushanim Hashim
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Appendix 2

Green Innovation Adoption Survey Questionnaire

The purpose of this 20-minute survey is to examine the level of green innovation adoption and investigate the way in which the Scottish construction firms manage the available and new related knowledge to facilitate the adoption of green innovation.

The anticipated benefits for your participation include gaining strategic insight to your firm's corporate strategy in adopting green innovation as well as understanding the initiatives related to green practices.

SECTION I: General Information - Respondent

Please provide some basic information about yourself.

1. What is your position within your firm?

- | | |
|---|---|
| <input type="checkbox"/> Managing Director/ CEO | <input type="checkbox"/> Project Manager |
| <input type="checkbox"/> Proprietor | <input type="checkbox"/> Research and Development Manager |
| <input type="checkbox"/> General Manager | <input type="checkbox"/> Technical Manager |
| <input type="checkbox"/> Other (Please specify):
_____ | |

2. How long have you worked with this firm?

- | | |
|---|---|
| <input type="checkbox"/> Less than 1 year | <input type="checkbox"/> 11-15 years |
| <input type="checkbox"/> 1-5 years | <input type="checkbox"/> 16-20 years |
| <input type="checkbox"/> 6-10 years | <input type="checkbox"/> 21 years or longer |

3. What is your gender?

- ☐ Male
☐ Female

4. How old are you?

- | | |
|---------------------------------------|---------------------------------------|
| <input type="checkbox"/> Less than 20 | <input type="checkbox"/> 40 – 49 |
| <input type="checkbox"/> 20 – 29 | <input type="checkbox"/> 50 and above |
| <input type="checkbox"/> 30 – 39 | |

5. What is the highest level of education completed?

- | | |
|--|--|
| <input type="checkbox"/> Vocational/Technical School | <input type="checkbox"/> Bachelor Degree |
| <input type="checkbox"/> High School | <input type="checkbox"/> Masters Degree |
| <input type="checkbox"/> College | <input type="checkbox"/> Doctoral Degree |

SECTION II: General Information - Company

Please provide some basic information about your firm.

1. How do you classify your firm? Please check all that apply.

- | | |
|---|--|
| <input type="checkbox"/> General contractor/builder | <input type="checkbox"/> Construction Management Firm |
| <input type="checkbox"/> Subcontractor | <input type="checkbox"/> Other (Please specify): _____ |

2. To which of the following industry sectors does your firm belong? Please check all that apply.

- | | |
|---|---|
| <input type="checkbox"/> Residential | <input type="checkbox"/> Industrial |
| <input type="checkbox"/> Commercial | <input type="checkbox"/> Heavy civil construction |
| <input type="checkbox"/> Other, please specify: | |

3. Is there any person explicitly responsible for environmental matters in your firm?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

4. Does your company have ISO14000?

- ☐ Yes, we are an ISO14000 certified company.
☐ No, we are not an ISO14000 certified company.
☐ We are in the process of applying for the certification.

5. How many people does your company employ?

No. of full time employee(s) : _____
No. of part time employee(s) : _____
No. of contract employee(s) : _____

6. Please indicate the number of years since the start-up of your firm :

7. Please indicate which of the following statement(s) describe the ownership of your firm. Please check all that apply.

- ☐ Our firm is not a family firm.
☐ Our firm is headed by a family member as Managing Director/ CEO/ Proprietor.
☐ One family owns at least 50 per cent of our company.
☐ At least two family members are active in our firm.
☐ Our firm is wholly-owned by one or more family members.

SECTION III: Existing Knowledge

Please indicate your level of agreement with the following statement:

(1=Strongly disagree, 2=Disagree, 3= Neutral, 4=Agree, 5=Strongly Agree)

- | | 1 | 2 | 3 | 4 |
|--|--------------------------|--------------------------|--------------------------|--------------------------|
| 5 | | | | |
| 1. Our employees' overall technical knowledge is high. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Our employees' general education level is high. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. Our employees' overall job competence is low. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. Our employees' general knowledge level is low. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. Please provide the percentage of employees with further education/ college qualification and higher.....% | | | | |

SECTION IV : Organisational Climate

Please indicate your level of agreement with the following statement:

(1=Strongly disagree, 2=Disagree, 3= Neutral, 4=Agree, 5=Strongly Agree)

- | | 1 | 2 | 3 | 4 | |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 5 | | | | | |
| 6. Our employees share ideas freely with each other | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 7. Our employees share an open communication environment | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 8. Our employees have no difficulty accepting new ideas | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 9. Our employees are willing to accept changes | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | |
| 10. What percentage of employees' work time is devoted to exploring new ideas/ creative activities?..... | | | | | |
| | 1 | 2 | 3 | 4 | 5 |
| 11. An adequate amount of training in environmental issues is provided for employees within our company. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 12. The employees receive environmental training frequently. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 13. The employees use their environmental training effectively. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 14. The employees have many opportunities to get environmental training. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 15. Our company invests a great deal in environmental training. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 16. Please provide the percentage of permanent employees involved in environmental training programmes:% | | | | | |

SECTION V: Knowledge Sources

Please indicate your level of agreement with the following statement:

(1=Strongly disagree, 2=Disagree, 3= Neutral, 4=Agree, 5=Strongly Agree)

The following sources are important for your firm in acquiring knowledge about environmental-related issues and development:

- | | 1 | 2 | 3 | 4 | 5 |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1. Conferences and fairs | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Literature and scientific papers | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. Professional associations (e.g. <i>Construction Industry Research and Information Association (CIRIA)</i> , <i>Building Research Establishment (BRE)</i> , etc.) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. Professional periodicals (e.g. <i>magazines, reports</i>) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. Media (e.g. <i>newspapers, television</i>) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. Information network (e.g. <i>Internet</i>) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 7. Suppliers | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 8. Customers | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 9. Competitors | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 10. Regulators | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 11. Environmental organisations (e.g. <i>Scottish Environment Protection Agency (SEPA)</i> , <i>Association for Environment Conscious Building (AECB)</i> , etc.) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 12. Universities | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 13. Research institutions | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 14. Industry association (e.g. <i>Scottish Building Federation (SBF)</i> , <i>Federation of Master Builders (FMB)</i> , etc.) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 15. How frequent are your firm's effort in getting environmental-related information from these sources? | | | | | |
| __Never | | | | | |
| __2 times per month | | | | | |
| __3 times per month | | | | | |
| __4 times per month | | | | | |
| __5 times per month | | | | | |
| __Once a year | | | | | |
| __Others (Please specify) | | | | | |
| 16. Approximately how many relationships do you have established with each party in regard to innovation initiatives or activities? | | | | | |

SECTION VI: Green innovation

Please indicate your level of agreement with the following statement:

(1=Strongly disagree, 2=Disagree, 3= Neutral, 4=Agree, 5=Strongly agree)

	1	2	3	4	5
1. Our company adopts the technologies of energy conservation (e.g. natural ventilation, thermal storage, solar heat, etc.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Our company adopts the technologies of recycling construction waste.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Our company adopts the technologies/ processes of pollution prevention (e.g. using water spray on dusty areas to reduce air pollution, offsite construction techniques which reduce on-site waste, etc.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Our company adopts the technologies of noise controlling (e.g. noise barriers, earth bunds or facade sound insulation, etc.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Emission of hazardous substances or waste during construction activities are monitored (e.g. minimise or eliminate toxic releases on site, etc.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Our company utilises, integrates with or recommends adoption of site waste management plans.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Energy is used efficiently during construction (e.g. low consumption of water and electricity).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Materials that require low energy to produce where possible are specified or used during construction (e.g. aggregate, timber, mud brick, stabilised earth, concrete blocks, etc.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Locally sourced materials are used for construction activities to reduce energy use of transport (e.g. procurement of locally produced products).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Natural environment is conserved during construction activities (e.g. protecting the site from undue damage to soils and vegetation).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. Our company adopts the natural environmental auditing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. Our company holds the natural environmental protective education and training.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. Our company offers the employee remuneration and promotion based on environmental initiative/improvement.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14. Our company promotes new activity or event for staff link to environmental-related issues.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15. Our company provides written environmental documentation such as policy, mission statement, rule or procedure to protect the environment.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16. Approximately what percentage of your company's annual capital budget is allocated to invest in green technologies?

<1% 5% 10% 15% 20% >25%

17. Approximately what percentage of your company's annual capital budget is allocated to spend on implementing green construction processes?

<1% 5% 10% 15% 20% >25%

18. Approximately what percentage of your company's annual capital budget is allocated to spend on green managerial practices?

<1% 5% 10% 15% 20% >25%

19. To what extent do you agree with the following statements related to "REGULATORY PRESSURE" as the "MAIN" driver of your firm's adoption of green practices?

1 2 3 4 5

19a. Environmental regulation is the primary driver for all our environmental activities

☐ ☐ ☐ ☐ ☐

19b. Our environmental activities are directed towards complying with regulations

☐ ☐ ☐ ☐ ☐

19c. Regulation by government agencies has greatly influenced our firm's environmental strategy

☐ ☐ ☐ ☐ ☐

19d. Environmental legislation is not relevant to our business

☐ ☐ ☐ ☐ ☐

20. To what extent do you agree with the following statements related to "CUSTOMER PRESSURE" as the "MAIN" driver of your firm's adoption of green practices?

1 2 3 4 5

20a. Customer pressure is the primary driver for all our environmental activities

☐ ☐ ☐ ☐ ☐

20b. Our customers expect our firm to be environmentally friendly

☐ ☐ ☐ ☐ ☐

20c. We engage in environmentally friendly activities because of customers' environmental consideration when making choices

☐ ☐ ☐ ☐ ☐

20d. Customers require detailed information to be assured of our environmental compliance

☐ ☐ ☐ ☐ ☐

Please provide any comments, feedback or suggestions.

Could I contact you if I have questions about your responses? If yes, please provide your contact detail below (Identities are kept CONFIDENTIAL):

Your name : _____

Company name : _____

Telephone number : _____

Email address : _____

Would you be willing to participate in an interview?

☐ YES

☐ NO

If yes, thank you for agreeing to contribute to the next stage of this project. You will be contacted very soon.

THANK YOU FOR YOUR PARTICIPATION.

Appendix 3

Sample Interview Questions (Building Firms)

- 1. Please kindly tell me a little bit about what you do – your current role in this company.**
How long have you work with this company?
- 2. Could you please tell me, briefly, about the background of the company /family business*?**
How long has this company been established?
Can you tell me why this company is established?
Please tell me who is responsible for setting the strategy/ planning the direction for the company.
*Please tell me about the number of generation that have been served in the business.
- 3. Please tell me about the construction services that are offered by your company.**
- 4. Can you tell me about your company's membership with any business or industrial associations?**
Please tell me what do you gain from being the member?
- 5. Please tell me about your any certification or accreditation for business practices that you had.**
How long have you had it?
Please tell me if you have any plan to apply for any certification.
- 6. Can you tell me, how many employees does your company have?**
Can you describe how competent they are in doing their job?
In your opinion, how open they are to any changes or new ideas?
- 7. Is there anyone responsible for environmental-related matters in your company?**
Please tell me about his/her role and responsibilities.
- 8. I am interested in knowing about your employees' development. Can you tell me how you develop your employees' environmental-related knowledge?**
Tell me if you have provided environmental training to them. Is it conducted internally or externally?
Could you mention the name of the some training programmes that you offer?
Please tell me about the benefits of the training.
Can you tell me about the problems that you have faced in conducting particular training?
Please tell me how you invest in providing the training.
- 9. In your opinion, how environmentally-friendly is your company?**
Tell me where is being green fit with your company's strategy.

10. I am interested in knowing about your company's knowledge in environmental-related issues or practices.

Could you please tell me how do you find information about environmental-related issues or practices?

Can you tell me about the most important source(s) that you think could provide valuable environmental-related information? How frequent do you use it?

11. I am interested in knowing about your company's relationship with others. Can you tell me if any of your contacts have provided or shared some extent of environmental-related information with your company?

Please tell me about those contacts and your relationship with them.

Can you tell me the way the information was obtained from them?

12. I am interested in knowing about your involvement in environmentally-friendly practices (in more specific). Can you tell me to what extent have you done to reduce the negative impacts to the environment while undertaking construction work?

What about the way you deal with construction waste?

How about construction material?

How do you manage the energy consumption during undertaking construction work?

How you move around or deal with transportation of goods?

How about physical surrounding of construction site?

13. Can you tell me about the technologies or equipment that your company uses to reduce negative impacts on the environment while undertaking construction work?

Please tell me for how long the technologies have been used.

Can you tell me the benefits of using the technologies?

Please tell me the challenges in using the technologies.

Do you have any plan to invest in any green-related technologies?

14. Can you tell me about any environmental-related activities that have been initiated to your employees?

How was the response from the employees? Are they still being implemented?

15. Can you tell me your company's motivation of involving in those environmentally-friendly practices that you have mentioned just now?

(Regulation) Which element of environmental legislation do you believe to be the most influential for your company? How do you respond to the legislation requirement?

(Customer) Can you tell me what do your customers want in regard to environmental consideration? In your opinion, how do your customers encourage you to try new things or become environmental-friendly

(Company's goal) How's the commitment from the management towards the environmental goals?

(Others) Can you tell me more about that?

How the motivations change through time?

16. Can you tell me about your company's achievement and area of improvement so far, through engaging in (I can say) some kind of environmental practices?

17. I would like to know about your company's future plan towards maintaining the environment.

Please tell me about your plan for additional development.

18. Is there anything else that you would like to add?

Appendix 4

Sample of Interview Questions (Industry Experts)

Firstly, I am interested in knowing about you and the organisation you work for.

1. Please kindly tell me a little bit about your role in this company/ practice.
2. How long have you worked with this company?
3. What did you do before starting/working at this company?
4. Please tell me about your membership with any professional body of architect.
5. What role of professional body of architect?
6. Could you please tell me, briefly, about the background of the company/ architect's practice?
7. How long has this company been established?
8. Can you tell me, how many employees does your company have?

I am interested in knowing about your company's knowledge of environmental-related issues or practices.

9. In your opinion, how aware is your company of environmental issues.
10. Could you tell me what aspect of environmental issues that your company aware of?
11. Can you explain to me how your awareness of environmental-related issues has been cultivated?
12. Please tell me what source you use to find environmental-related information?

I am interested in knowing about your role as an architect and the work you undertake as it relate to environmental issues.

13. Please tell me what are the roles and responsibilities of an architect.
14. Can you briefly describe the flow of the planning and design process?
15. Could you tell me what factors influence your design decision?
16. Does your company incorporate green elements into design work?
17. How important of environmental issues in design decision?
18. Are environmental factors considered in every design?
19. How the architect professional body (e.g. RIBA) influences/encourages architects to incorporate or use environmentally-friendly practices in design work?
20. Do the planning authorities influence the incorporation of environmentally-friendly elements into your design work? How?
21. Could you please tell me some examples of environmentally-friendly aspects that are commonly considered in your designs?
22. Tell me who normally you work or liaise with in completing a construction project?
23. Could you please describe the flow/ chain of command in executing a construction project?
24. How do you work with contractors/builders? How often do you have discussion with them when implementing a particular project?
25. Who normally incorporate green ideas in building construction project?

26. Do contractors/builders come forward with green idea?
27. In your opinion, do architects influence the contractors/builders to adopt any environmental-friendly practices while undertaking construction work?
28. Tell me how you would be able to influence them.
29. Is there any other party that you think could influence contractors/builders to use environmentally-friendly approaches in implementing construction projects?

30. Overall, what do you think is the most influential factor that could drive contractor/builder to adopt environmental-friendly practices while undertaking construction work?
31. Can you tell me what might be the most effective way to increase the adoption of green approaches in executing a construction project?